HYDAC FILTER SYSTEMS

CS1000 series ContaminationSensor

Operating and Maintenance Instructions

English (translation of original instructions)

Valid from:

- Firmware version V 3.00
- Hardware index F
- Serial number: 0002S01515K0004000

Document No.: 3764916

Imprint

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Preface

For you, as the owner of a product manufactured by us, we have produced this manual, comprising the most important instructions for its **operation** and **maintenance.**

It will acquaint you with the product and assist you in obtaining maximum benefit in the applications for which it is designed.

You should keep it in the vicinity of the product so it is always at your fingertips.

Note that the information on the unit's engineering contained in the documentation was that available at the time of publication.Consequently, there might be deviations in technical details, illustrations and dimensions.

If you discover errors while reading the documentation or have suggestions or other useful information, please don’t hesitate to contact us:

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Germany

We look forward to receiving your input.

“Putting experience into practice”

Technical Support

If you have any questions, suggestions, or encounter any problems of a technical nature, please don't hesitate to contact us. When contacting us, please always include the model/type designation and article no. of the product:

Fax: ++49 (0) 6897 / 509 - 846

E-Mail: filtersystems@hydac.com

Modifications to the Product

We would like to point out that changes to the product (e.g. purchasing options, etc.) may result in the information in the operating instructions no longer being completely accurate or sufficient.

When making modifications or performing repair work to components affecting the safety of the product, the product may not be put back into operation until it has been examined and released by a HYDAC representative.

Please notify us immediately of any modifications made to the product whether by you or a third party.

Warranty

For the warranty provided by us, please refer to the General Terms of Sale and Delivery of HYDAC Filter Systems GmbH.

You'll find this under www.hydac.com -> Legal information

Using the documentation

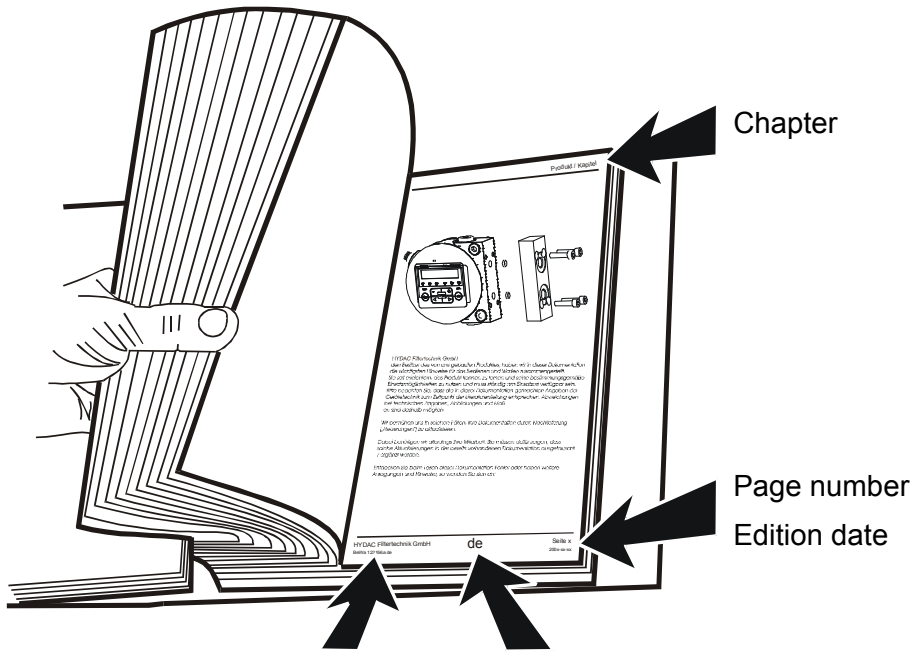
Note that the method described for locating specific information does not release you from your responsibility of carefully reading these instructions prior to starting the unit up for the first time and at regular intervals in the future.

WHAT do I want to know?

I determine which topic I am looking for.

WHERE can I find the information I'm looking for?

The document has a table of contents at the beginning. I select the chapter I'm looking for and the corresponding page number.



The documentation number with its index enables you to order another copy of the operating and maintenance instructions. The index is incremented every time the manual is revised or changed.

Safety information

These operating instructions contain the key instructions for properly and safely operating the CS.

Obligations and Liability

The basic prerequisite for the safe and proper handling and operation of the CS is knowledge of the safety instructions and warnings.

These operating instructions in general, and the safety precautions in particular, are to be adhered to by all those who work with the CS.

Adherence is to be maintained to pertinent accident prevention regulations applicable at the site where the product is used.

The safety guidelines listed here are restricted to use of the CS.

The CS has been designed and constructed in accordance with the current state of the art and recognized safety regulations. Nevertheless, hazard may be posed to the life and limb of the individual using the product or to third parties. Risk of damage may be posed to the product or other equipment and property.

Use the CS:

- Solely for its designated use
- only when in a safe, perfect condition

Our General Terms and Conditions apply. They are provided to the owner upon conclusion of purchase of the unit at the latest. Any and all warranty and liability claims for personal injuries and damage to property shall be excluded in the event they are attributable to one or more of the following causes:

- improper use of the CS or use deviating from its intended use
- Improper assembly/installation, start up, operation and maintenance of the CS
- modifications to the CS made by the user or purchaser
- Improper monitoring of unit components that are subject to wear and tear
- Improperly performed repair work

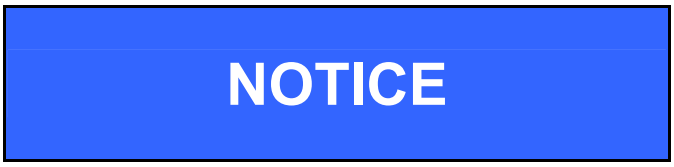
Explanation of Symbols and Warnings, etc.

The following designations and symbols are used in this manual to designate hazards, etc.:

DANGER denotes situations which can lead to death if safety precautions are not observed.

WARNING denotes situations which can lead to death if safety precautions are not observed.

CAUTION denotes situations which can lead to severe injuries if safety precautions are not observed.



NOTE denotes situations which can lead to property damage if safety precautions are not observed.

Proper use

The ContaminationSensor module CS1000 was developed for the continuous monitoring of particulate contamination in hydraulic and lubrication systems.

Analyzing the size and quantity of contamination enables quality standards to be verified and documented, and the requisite optimization measures to be implemented.

Improper use or use deviating from intended use

Improper use may result in hazard to life and limb.

Improper use is:

- Improper connection of the CS voltage and sensor cables.
- Operation with a non-approved fluid.
- Operation with impermissibly high pressure

WARNING

Hydraulic systems are under pressure

Danger of bodily injury

► The hydraulic system must be depressurized before performing any work on the hydraulic system.

Training and Instruction of Personnel

The CS may only be operated by properly trained and instructed personnel.

The areas of responsibility of your staff must be established in a clear-cut manner.

Staff undergoing training may not use the CS unless supervised by an experienced staff member.

Individuals / Activity	Individuals undergoing training	Individuals with technical training/ engineering background	Electrician	Supervisor with the appropriate authority
Packing Transportation	X	X		X
Commissioning		X	X	X
Operation	X	X	X	X
Troubleshooting/ locating the source of malfunction		X	X	X
Remedying faults Mechanical		X		X
Troubleshooting, electrical problem			X	X
Maintenance	X	X	X	X
Servicing				X
Decommissioning/storage	X	X	X	X

Storing the CS

Store the CS in a clean, dry place, in the original packing, if possible. Do not remove the packing until you are ready to install the unit.

Rinse the CS completely with Cleanoil before putting it into storage.

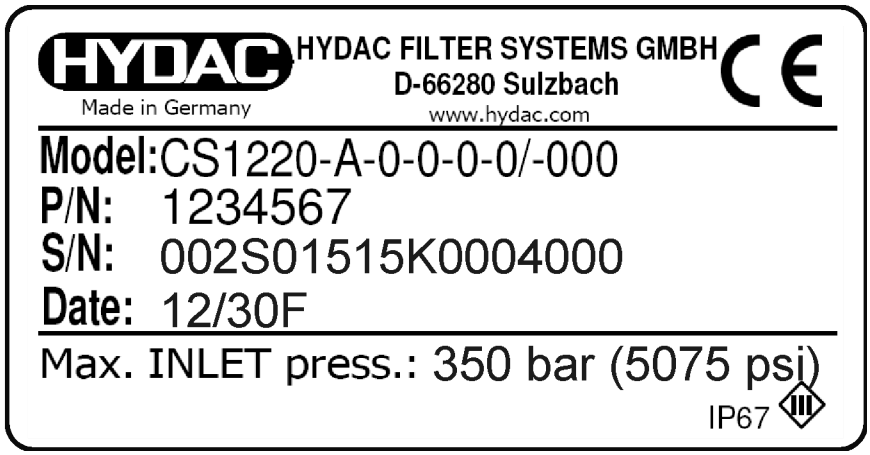
The solvents and flushing oils used must be handled and disposed of correctly.

Storage conditions

Storage temperature:	-40 °C … 80 °C / -40 °F … + 176 °F
Relative humidity:	maximum 95%, non-condensing

Decoding the model code label

For product identification details see the Model code label. This is located on the back of the unit and contains the exact product description and the serial number.



Row	->	Description
Model	->	Model code; for details, see page 106
P/N	->	Part no.
S/N	->	Serial no.
Date	->	Year/week of production and hardware index
Max. INLET press.:	->	Maximum operating pressure

Checking the scope of delivery

The ContaminationSensor CS1000 comes packed and factory-assembled, ready for operation. Before starting up the CS, check that the content of the package is complete.

The following items are supplied:

Qty.	Code
1	ContaminationSensor, CS1000 series (Model in acc. with the order - see model code)
2	O-Ringe (Only with connection type "Flange connection" = model code: CS1xxx-x-x-x-x-1/-xxx)
1	FMM-P upgrade kit with installation instructions (Only with connection type "Flange connection" = model code: CS1xxx-x-x-x-x-1/-xxx)
1	CD with CS1000 operation and maintenance instructions (this document in various languages)
1	CD with FluMoS software (fluid monitoring software)
1	Quick start manual
1	Calibration certificate

CS 1x2x CS 1x1x

CS1000 Features

The CS1000 Series Contamination Sensor is a stationary measurement unit for the continuous monitoring of particulate contamination in hydraulic and lubrication systems.

The CS is designed to be used in low- or high-pressure hydraulic and lubrication circuits and test benches where a small amount of oil (between 30 ml/min and 500 ml/min) is diverted for measurement purposes.

The ContaminationSensor is approved for a maximum operating pressure (see specification on type label) and viscosity of up to 1000 mm²/s.

Particulate contamination is detected with an optical measurement cell

The sensor is available with the following options:

- with or without 6-digit display and keypad (can be rotated by 270°)
- with a 4 … 20 mA or 2 … 10 V analog output
- Results are output as a cleanliness code according to:
  ISO 4406:1999 and SAE AS 4059(D) or
  ISO 4406:1987 and NAS or ISO4406:1999 and SAE AS 4059(D)
- pipe / hose installation or flange installation

All models feature an analog electric output and an RS485 interface for outputting the measured cleanliness class. In addition, all CS1000's have a switching output.

CS1000 Restrictions on use

NOTICE

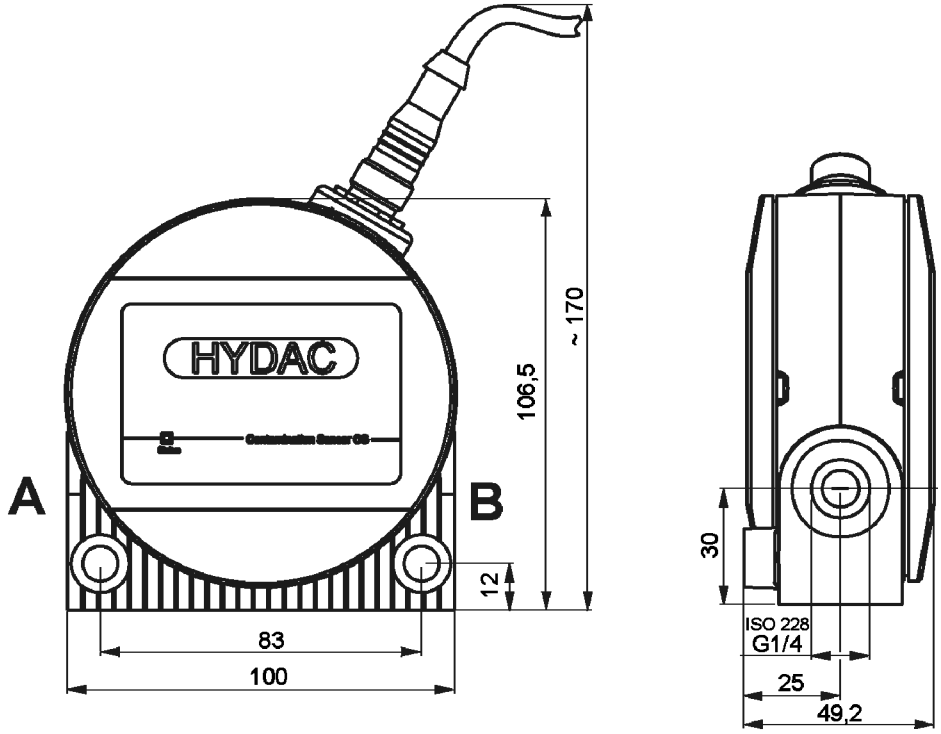
Impermissible operating media

The ContaminationSensor will be destroyed.

► Operate the CS1000 only with the permissible operating fluids:
- **CS 1xx0** is suitable for operation with mineral oils or mineral-oil-based raffinates.
- **CS 1xx1** is suitable for phosphate esters.

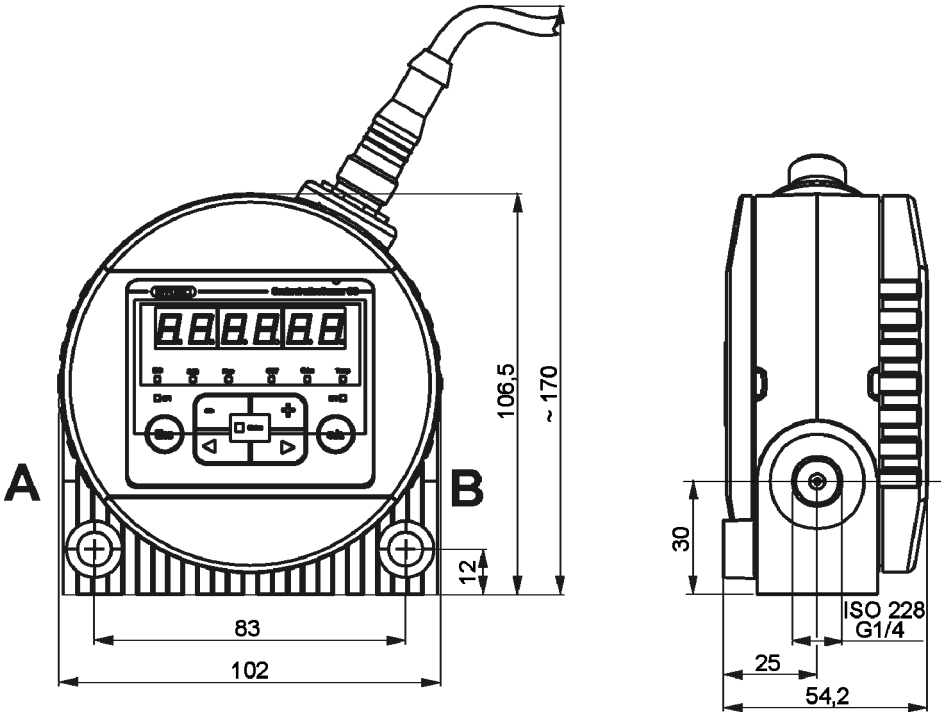
► Note the maximum operating pressure of 350 bar / 5075 psi.

CS1x1x dimensions (without display)



All dimensions in mm.

CS1x2x dimensions (with display)



All dimensions in mm.

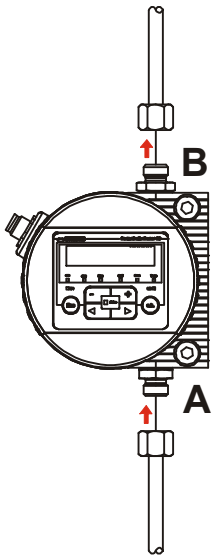
Hydraulic connection types

Install the CS in such a way that the flow runs from bottom to top. Use port A / C as the INLET and B / D as the OUTLET.

Pipe or hose connection (type CS1xxx-x-x-x-x-0/-xxx)

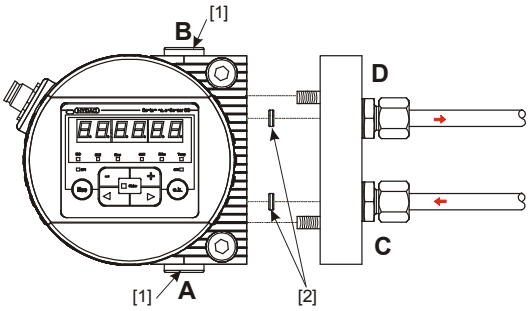
Hydraulic connection is done via ports A and B. Connection thread G1/4 according to ISO 228.

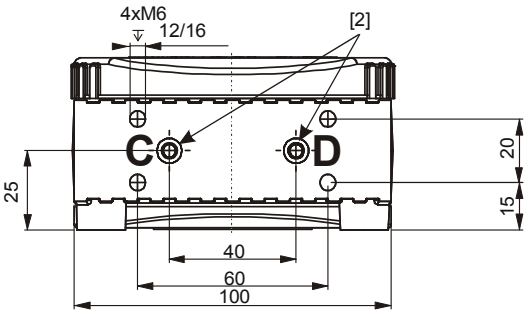
Make sure that the flow runs through the sensor from bottom (A) to top (B).



Flange connection type (Type CS1xxx-x-x-x-x-1/-xxx)

Hydraulic connection is done via ports C and D. Two O-rings are used to form a seal between the CS and a flange, connecting plate or manifold mount. Four M6 threads are prepared for fixing the CS1000. Ports A and B are sealed off with screw plugs [1]. Sealing with the manifold block or mounting plate is done via two O-rings [2] (4.48 x 1.78 FPM, see Chapter "Spare Parts + Accessories").





View from below.
All dimensions in mm.

Fastening / mounting the CS1000

Install the CS in such a way that the flow runs from bottom to top.

Use the one (lower) port as the INLET and the other (upper) port as the OUTLET.

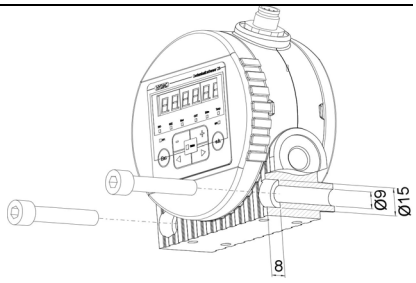
When selecting the installation site, take ambient factors like the temperature, dust, water, etc. into account.

The CS1000 is designed for IP67 according to DIN 40050 / EN 60529 / IEC 529 / VDE 0470.

Mount the sensor as shown in the following examples:

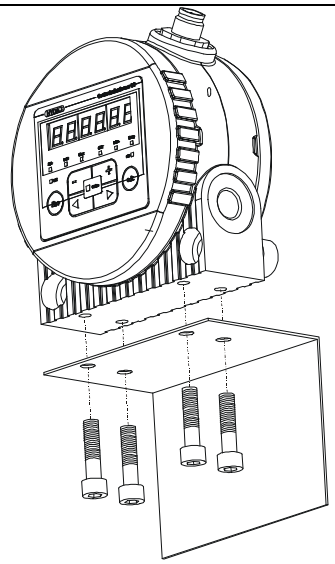
1. Wall mounting:

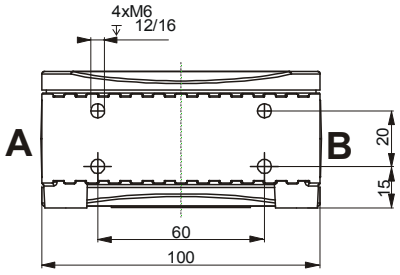
Mount to a wall using two cylindrical screws having an M8 hexagonal socket according to ISO 4762 and having a length of at least 40 mm.



2. Console mounting:

Mount to a console using 4 cylindrical screws having an M6 hexagonal socket according to ISO 4762.



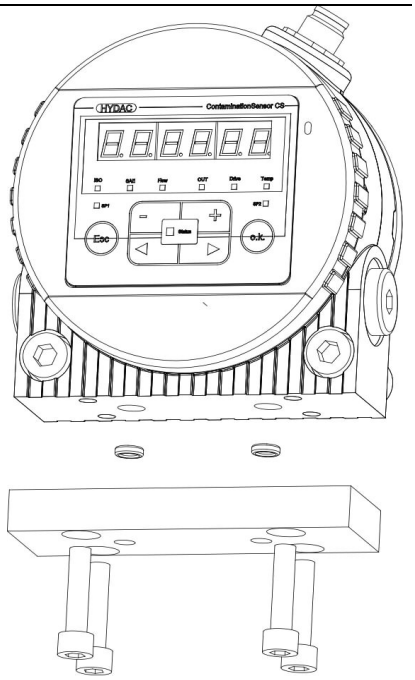


Bottom view

All dimensions in mm.

3. Mounting to a mounting plate:

Mount to a mounting plate or control block using 4 cylindrical screws having an M6 hexagonal socket according to ISO 4762.

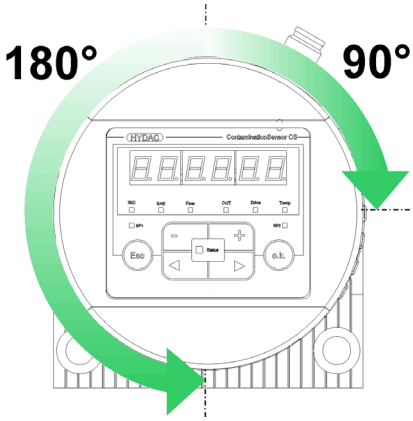


Display rotatable/Adjustable As Needed

The display can be continuously rotated by a total of 270°; 180° counterclockwise and 90° clockwise.

Rotate the display by hand in the corresponding direction.

No tools are required for rotating the display.



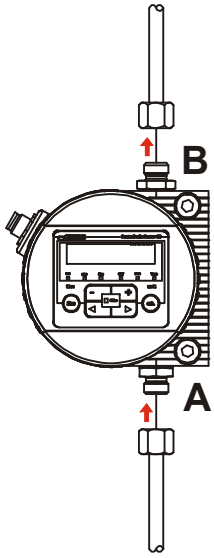
CS1000 hydraulic installation

Install the CS in such a way that the flow runs from bottom to top. Use port A / C as the INLET and B / D as the OUTLET.

Depending on your order, the CS features the following hydraulic connection types:

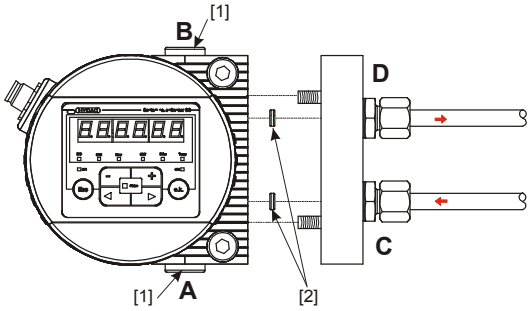
Pipe/hose connection

The CS is connected to the hydraulic system via ports A and B using a pipe or hose.



Flange connection

The CS is screwed to a flange, connecting plate, manifold mount or control block, with flow through the unit via ports C and D on the bottom. Ports A and B exist but are sealed with a screw plug.



Determine the operating pressure of the hydraulic system and see whether it is within the permissible flow range for the CS inlet.

NOTICE

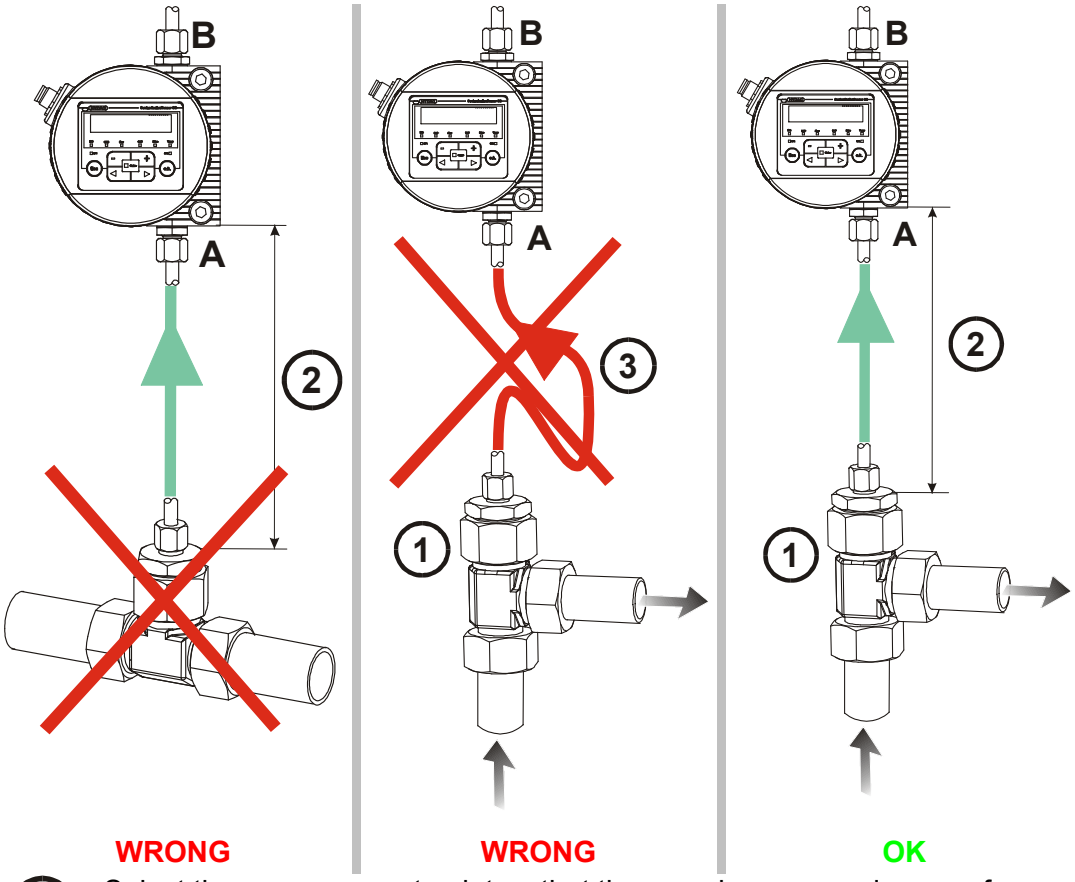
Excessive operating pressure

The ContaminationSensor will be destroyed.

► Note the maximum operating pressure of 350 bar / 5075 psi.

Selecting the measurement point

In order to obtain cleanliness values that are continuous and coherent in real time, select a suitable measuring point according to the following guidelines:



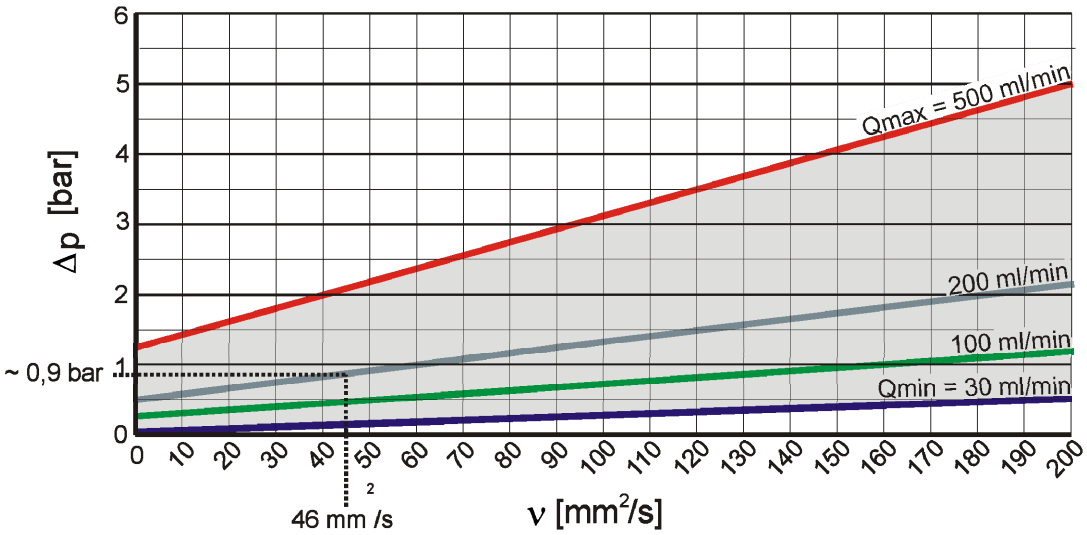
1. Select the measurement point so that the sample measured comes from a turbulent location, with a good flow. For example: on a pipe elbow, etc.
2. Install the sensor near the measurement point to achieve as timely results as possible.
3. During installation, avoid creating a "siphon" trap for particle deposits in the line (sedimentation).

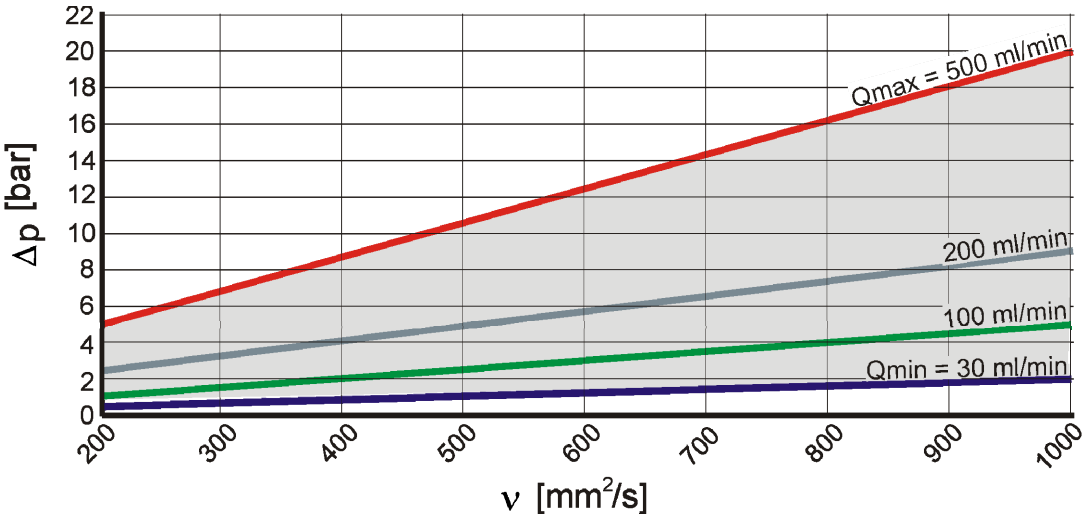
Flow rate, differential pressure Δp and viscosity ν characteristics

Differential pressure Δp and viscosity ν characteristics. All the values indicated in the figures below apply regardless whether the direction of flow is A->B or B->A.

Note that the permissible measured volumetric flow is 30 … 500 ml/min.

If you are unable to achieve the required flow values, we offer an extensive line of accessories with various conditioning modules.





For example:

You are using a fluid with a viscosity ν of 46 mm²/s at a pressure difference Δp of ~0.9 bar, so that you achieve a flow rate of approx. 100 ml/min.

The flow rate depends on the viscosity of the medium and the differential pressure Δp via the sensor.

Hydraulic connection of the CS1000

NOTICE

Excessive operating pressure

The ContaminationSensor will be destroyed.

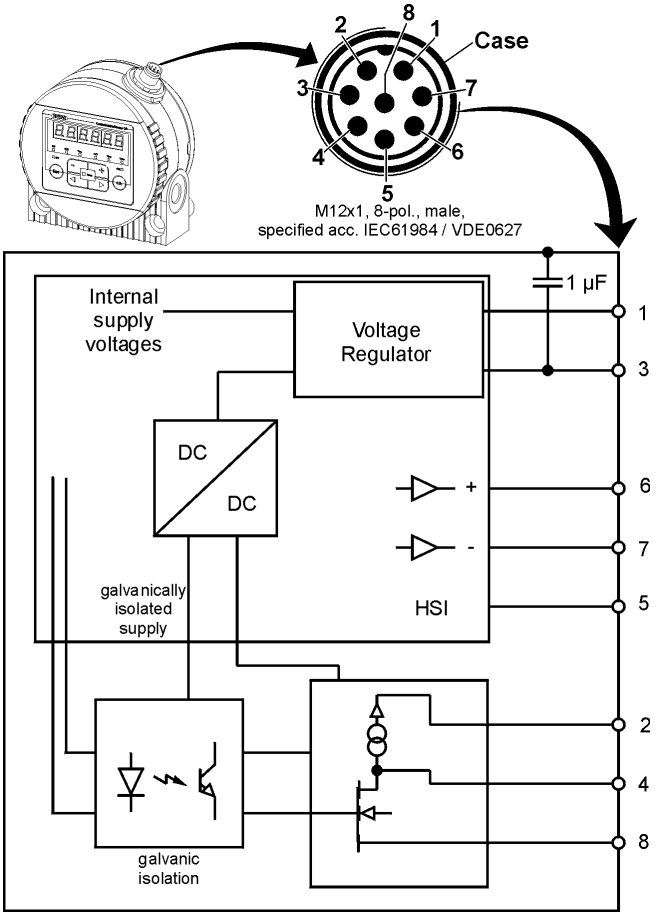
► Observe the maximum operating pressure of 350 bar / 5075 psi.

Observe the following sequence when connecting the sensor to the hydraulic system:

1.	Connect the return line to the outlet of the CS. G1/4 ISO 228 threaded connection, recommended diameter of line ≥ 4 mm.
2.	Then connect the other end of the return line to the system tank, for example.
3.	Check the pressure at the measurement location. Note the maximum operating pressure.
4.	Connect the measurement line to the inlet of the CS. G1/4 ISO 228 threaded connection. We recommend an internal Ø ≤ 4mm for the line in order to prevent particle deposits (sedimentation). If particles ≥ 400 µm are anticipated in the hydraulic system, install a strainer upstream from the ContaminationSensor. (e.g. CM-S).
5.	Connect the other end of the measurement line to the measurement point on the hydraulic system. Oil begins to flow as soon as the ContaminationSensor is connected with the pressure line.
6.	The hydraulic connection is complete.

Electrical connection of the CS1000

Pin assignment



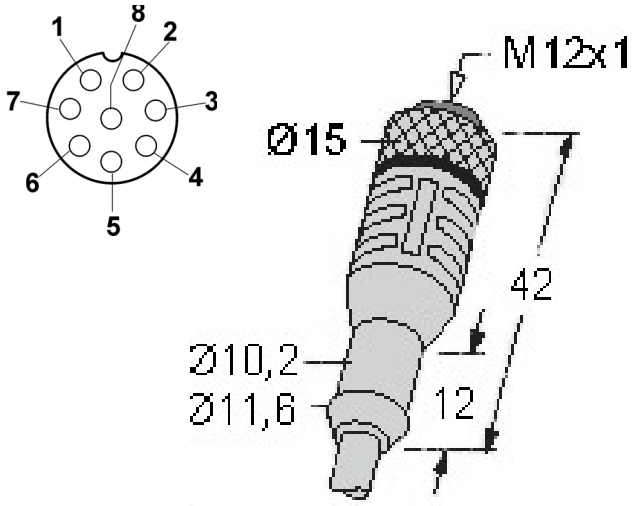
Pin	Assignment
1	Supply voltage 9 ... 36 V DC
2	Analog output + (active)
3	GND supply voltage
4	GND ANALOG / SWITCH OUTPUTS
5	HSI (**H**YDAC **S**ensor **I**nterface)
6	RS485 +
7	RS485 -
8	Switching output (passive, n.c.)

The analog output is an active source of 4 ... 20 mA or 2 ... 10 V DC.
The switching output is a passive n-switching power MOSFET and is normally open.
There is contact between the plug housing and the housing.

Connection cable - assignment / color coding

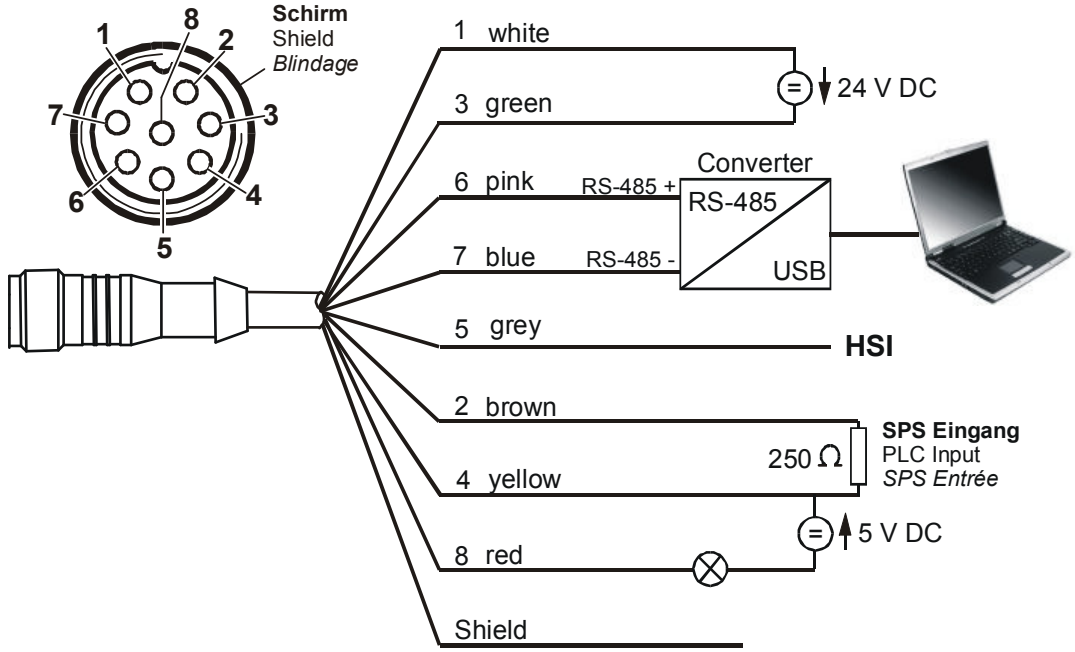
Our accessories list on page 95 includes the required connection cables of various lengths with one connection plug (8-pole, M12x1, according to DIN VDE 0627) and an open end.

HYDAC accessory cable color coding is listed in the table below.

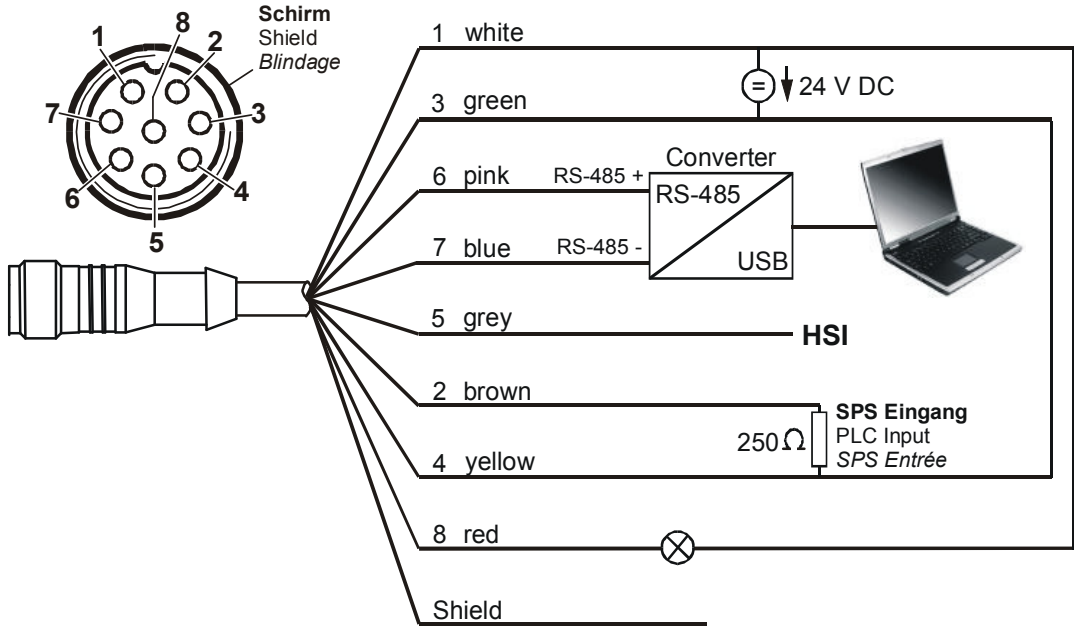


Pin	Colour	Connection to
1	White	Supply voltage 9 ... 36 V DC
2	brown	Analog output + (active)
3	Green	GND supply voltage
4	yellow	GND ANALOG / SWITCH OUTPUTS
5	grey	HSI (**H**YDAC **S**ensor **I**nterface)
6	Pink	RS485 +
7	blue	RS485 -
8	Red	Switching output (passive, n.c.)
Housing	-	screen

Connecting cable ends - Examples



Circuit diagram: with two separate power supplies. (e.g. 24 V DC and 5 V DC)



Circuit diagram: with one power supply. (e.g. 24 V DC).

To prevent a ground loop, connect the shield of the connector cable if and only if the CS1000 is not grounded or not sufficiently connected to the PE conductor.

Setting the measuring mode

Once the sensor is switched on or supplied with power, it automatically runs in the measuring mode that has been set.

Mode M1: Continuous measurement

Application:	Stand-alone sensor
Data output:	Display & RS485 & analog output
Purpose:	Measurement only
Function:	Continuous measurement of cleanliness class Switching function only for "Device ready".

Mode M2: Continuous measurement and switching

Application:	Stand-alone sensor with alarm standby display
Data output:	Display & RS485 & analog output & switching output
Purpose:	Continuous measurement and controlling of signal lamps etc.
Function:	Continuous measurement of solid contamination, continuous monitoring of programmable limit values; switching output is activated to switch on the monitor display or an alarm on site

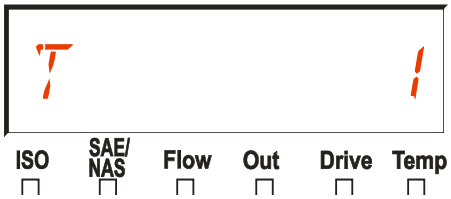
Mode M3: Filter to cleanliness class and stop

Application:	Controlling a filter unit
Data output:	Display & RS485 & analog output & switching output
Purpose:	For cleaning up a hydraulic reservoir
Function:	Control of a filter unit, continuous measurement of solid contamination. If pre-programmed cleanliness level is achieved 5 times in sequence, the pump is stopped. Load the switching output with a maximum of 2 A and 30 V DC.

Mode M4: Filter to continuously monitor cleanliness class

Application:	Control of stationary offline filtration unit
Data output:	Display & RS485 & analog output & switching output
Purpose:	Establish continuous monitoring of cleanliness class between min./max. limit values.
Function:	Control of a filter unit, continuous measurement of solid contamination. If min./max. limit values are pre-programmed, the CS switches the filtration unit on/off to maintain the cleanliness within the limit value range.

Once the target cleanliness has been reached (5x undershooting of the TARGET), the set test cycle time in minutes appears on the display. The test cycle time expires.



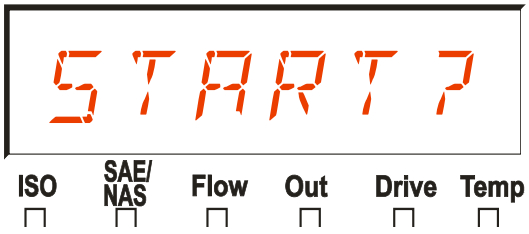
After the test cycle time has elapsed, the switching output is closed and a measurement is started. If the result is still below the TARGET cleanliness, the test cycle time (CYCLE) begins again.

Mode "SINGLE" measurement

Application:	Stand-alone sensor
Data output:	Display & RS485 & analog output
Purpose:	Perform a single measurement and "stop" the result.
Function:	Single measurement of solid contamination without switching functions

When Single mode is selected in the PowerUp menu, the display jumps directly to the following message after switching to the Measuring menu or after switching the CS on:

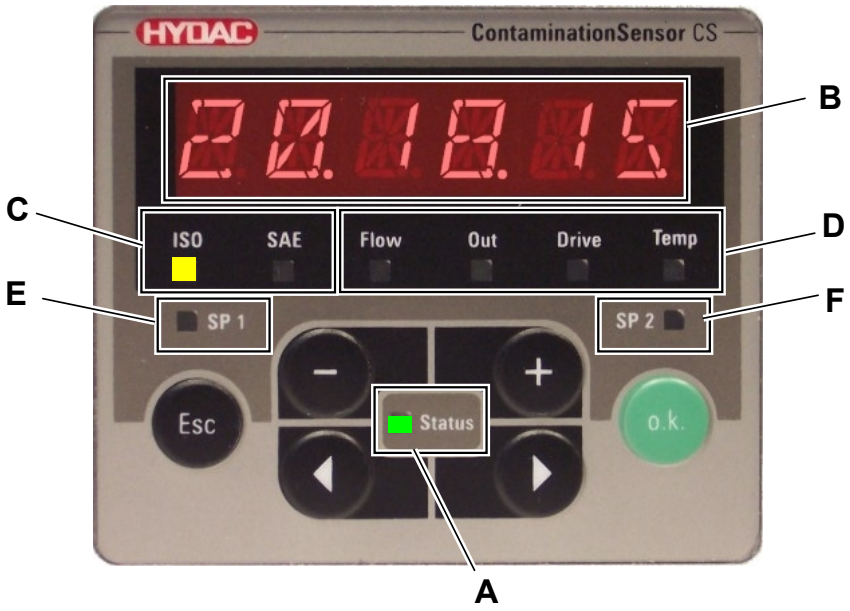
The CS begins with individual measurement after the message has been confirmed by pressing o.k. .



Operating the CS1x2x using the keypad

If the sensor is switched on or supplied with power, the display shows HYDAC CS1000 in moving letters, then the firmware version is displayed for 2 seconds.

This is followed by a countdown: WAIT99 ... WAIT0.
The duration of the countdown corresponds to the set measurement time MTIME. This means that the countdown runs from 99 ... 0 within the set measurement time (factory setting = 60 sec).



Item	LED	Description	For details, see page
A	Status	Status display	86
B	Display	6-figure display with 17 segments each	86
C	Measured variable	Display of respective measured variable, e.g: **ISO / SAE / NAS**	32
D	Additional variable	Display of respective service variable, e.g.: **Flow / Out / Drive / Temp**	33
E	Switch point 1	Indicates the status of the switching output. When the LED is lit, the switching output is activated, i.e. the switch is closed.	52
F	Switch point 2	Reserved	

Function of the Keys

The following keys are available to you for operating and setting the CS1x2x.

Key	Function
o.k.	You jump one menu level down. You confirm a changed value at the lowest menu level. You confirm at the top menu level to save or reject a change in value.
Esc	You jump up one menu level. In order to leave the menu without changing the values, press the ESC key until SAVE appears in the display. With the ◀ ▶ keys switch to CANCEL and confirm with the o.k. key or wait 30 seconds without pressing a key. You exit the menu without changing the values.
− +	You change values / settings on the lowest menu level.
◀ ▶	You scroll through the display **ISO / SAE/NAS / Flow / Out / Drive / Temp**. You move through the menu. You select numbers.

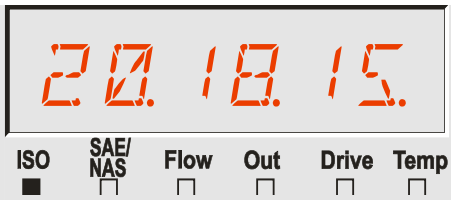
Once the lowest menu level has been reached, the values in the display will start to flash.

Measured variables on the display

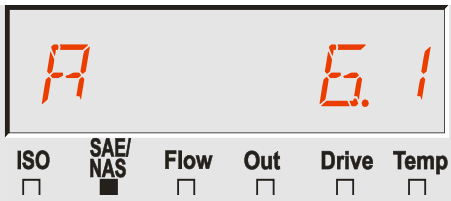
The measured variables give you information on the oil cleanliness in the system.

You will gain a measured value with an accuracy of ± 1/2 ISO code within the calibrated range.

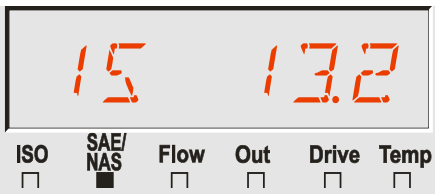
ISO (Cleanliness class)

Display	Description
	Measured value ISO code

SAE (Cleanliness class)

Display	Description
	SAE class measurement category

NAS (Cleanliness Class - only CS 13xx)

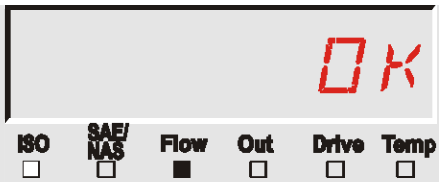
Display	Description
	NAS class measurement category

Service variables on the display

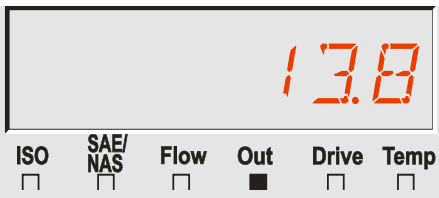
The service variables inform you about the current status in the ContaminationSensor.

The service variables are not calibrated. They represent an approximate value for installing the sensor in the hydraulic system.

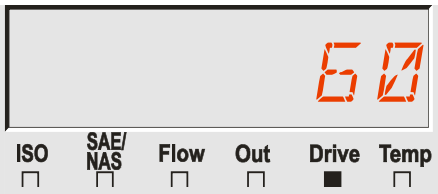
Flow (flow rate)

Display	Description
	Flow rate in permissible range

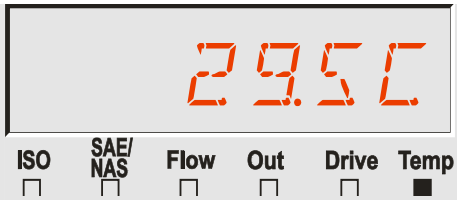
Out (Analog output)

Display	Description
	Current or voltage output at the analog output. (example: 13.8 mA)

Drive (performance of the LED)

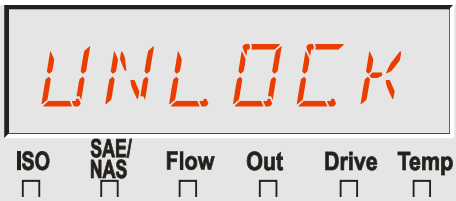
Display	Description
	Performance (1-100%) of the LED in the sensor.(example: 60%)

Temp (Temperature)

Display	Description
	Fluid temperature in the sensor. (example: 29.5 °C or 84.2 °F)

Activate / deactivate keypad lock.

Activate or deactivate the keypad lock by pressing both keys simultaneously. When the keypad lock is activated, the keypad is locked to prevent further input.

Keys	The following appears in the display (1 sec)	Description
		Activating key lock
		Deactivating key lock

The display switches to the preset display after 1 second.

When the supply voltage to the CS is disconnected, the activated keypad lock "LOCK" is unlocked and reset to "UNLOCK".

Display FREEZE

This function makes it possible for you to call up the last 20 displayed values on the display.

The active display is then frozen in the set MTIME cycle.

The display FREEZE function is based on a volatile memory and means that the values can be called up only as long as the CS is supplied with power and the sensor is in display FREEZE.

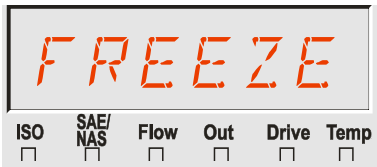
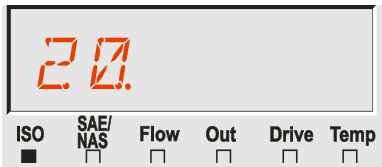
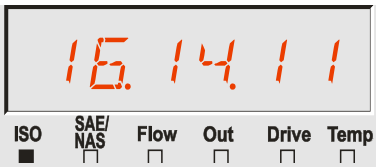
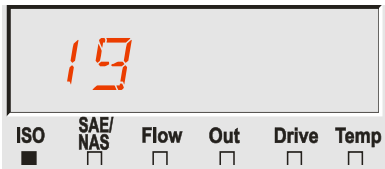
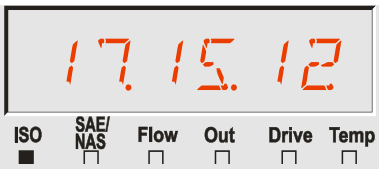
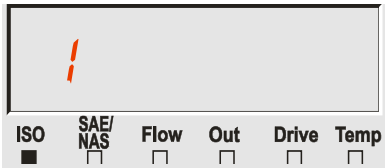
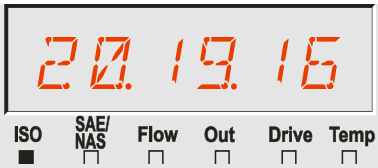
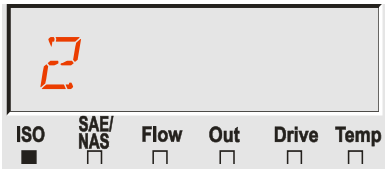
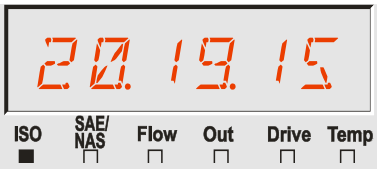
The measured values are automatically numbered, whereby the highest incremental number represents the last measured value. That means that when the memory is full (20 measured values), the value 20 is the most recent and the value 1 is the oldest .

If the memory exceeds 20 display values, the oldest entry will be overwritten.

Activate display FREEZE

To activate or deactivate the history memory FREEZE, press both keys simultaneously.

The FREEZE function starts with the display of the most recent measured value.

Keys	The following appears in the display (1 sec)	<->	The following appears in the display (3 sec)
◀ ▶			
		<->	
◀		<->	
◀	…	<->	…
◀		<->	
▶		<->	

Deactivate display FREEZE

If display FREEZE is set to MANUAL in the PowerUp menu:

Press the following two keys simultaneously to return to the current display:

	The display switches to the preset display. All values present in the FREEZE memory are deleted.

If the display FREEZE is set to TIMEOUT in the PowerUp menu:

You are returned automatically to the current display after 10 times the value for MTIME, or manually by pressing both arrow keys simultaneously.

The factory setting of MTIME is 60 seconds x 10 = 600 seconds = 10 minutes.

Menus and modes

The sensor has the following two operating levels / menus.

Menus	Mode	Description	Page
PowerUp Menu	PowerUp Mode	You carry out the basic settings in this menu.	36
Measuring Menu	Measurement mode	This menu starts automatically after powering up.	40 / 44

PowerUp Menu

You can carry out the basic settings for operation of the CS in the PowerUp menu.

Selection	To do
Start the PowerUp menu	Press any key while the supply voltage to the sensor is switched on / generated.
Exit the PowerUp menu without saving	Scroll through to CANCEL and press the o.k.-key. If a key is not pressed within 30 seconds, the system jumps back automatically.
Exit the PowerUp menu after saving.	Scroll through to SAVE and press the o.k.-key.

PowerUp Menu:		Code
	MODE	*Select measurement mode*
	MTIME	*Set measuring duration*
	PPRTCT	*Set pump protection time*
	ADRESS	*Set bus address*

	CALIB	*Select calibration (only 13xx)*
	FREEZE	*Set history memory*
	DFAULT	*Reset CS to factory default settings*
	CANCEL	*Discard changes and exit*
	SAVE	*Save changes and exit*
	CODE	*For internal use only*

MODE	*Select measurement mode*	⊕ ⊖	**Code**
		M 1	*Continuous measurement*
		M2	*Continuous measurement and switching*
		M3	*Filter to cleanliness class and stop*
		M4	*Filter with continuous monitoring*
		SINGLE	*Single measurement*

MTIME	*Set measuring duration*	◀ ▶ ⊕ ⊖	**Code**
		60	*Set measuring duration (10 ... 300 seconds)*

P.PRTCT	*Set pump protection time*	⊕ ⊖	**Code**
		0	*0 ... 10 number of measurement cycles.* *Make sure that the pump can run dry at an M.Time setting of 300 * 10 = 3000 seconds = 50 minutes.*

ADRESS	Set bus address	◀ ▶	⊕ ⊖	**Code**
		HECOM		
			A	*(a,b, … z)*
		IP		
			NO SET	
		MODBUS		
			NO SET	

CALIB	Select calibration	◀ ▶	*Available for model CS 13xx only!*
		ISO.SAE	*ISO4406:1999 / SAE*
		ISO.NAS	*ISO4406:1987 / NAS*

FREEZE	FREEZE setup	◀ ▶	
		OFF	*Display function FREEZE switched off*
		MANUAL	*Return to display manually via the key combination ◀ ▶* *For details see page 29.*
		TIMOUT	*Return to display automatically after 10x the measurement duration MTIME.*
DFAULT	Resetting to factory setting		*Generate factory setting.* *For factory settings see page 101.*
CANCEL	Discard changes and exit		
SAVE	Save changes and exit		
CODE	Activates the service menu		*For internal use only*

Measuring Menu (CS12xx)

During measurement operation, you can perform the following settings:

Selection	To do
Start the measuring menu	Press the o.k. key.
Exit the measuring menu without saving	Scroll through to CANCEL and press the o.k.-key. If a key is not pressed within 30 seconds, the system jumps back automatically.
Save and exit the measuring menu	Scroll through to SAVE and press the o.k.-key.

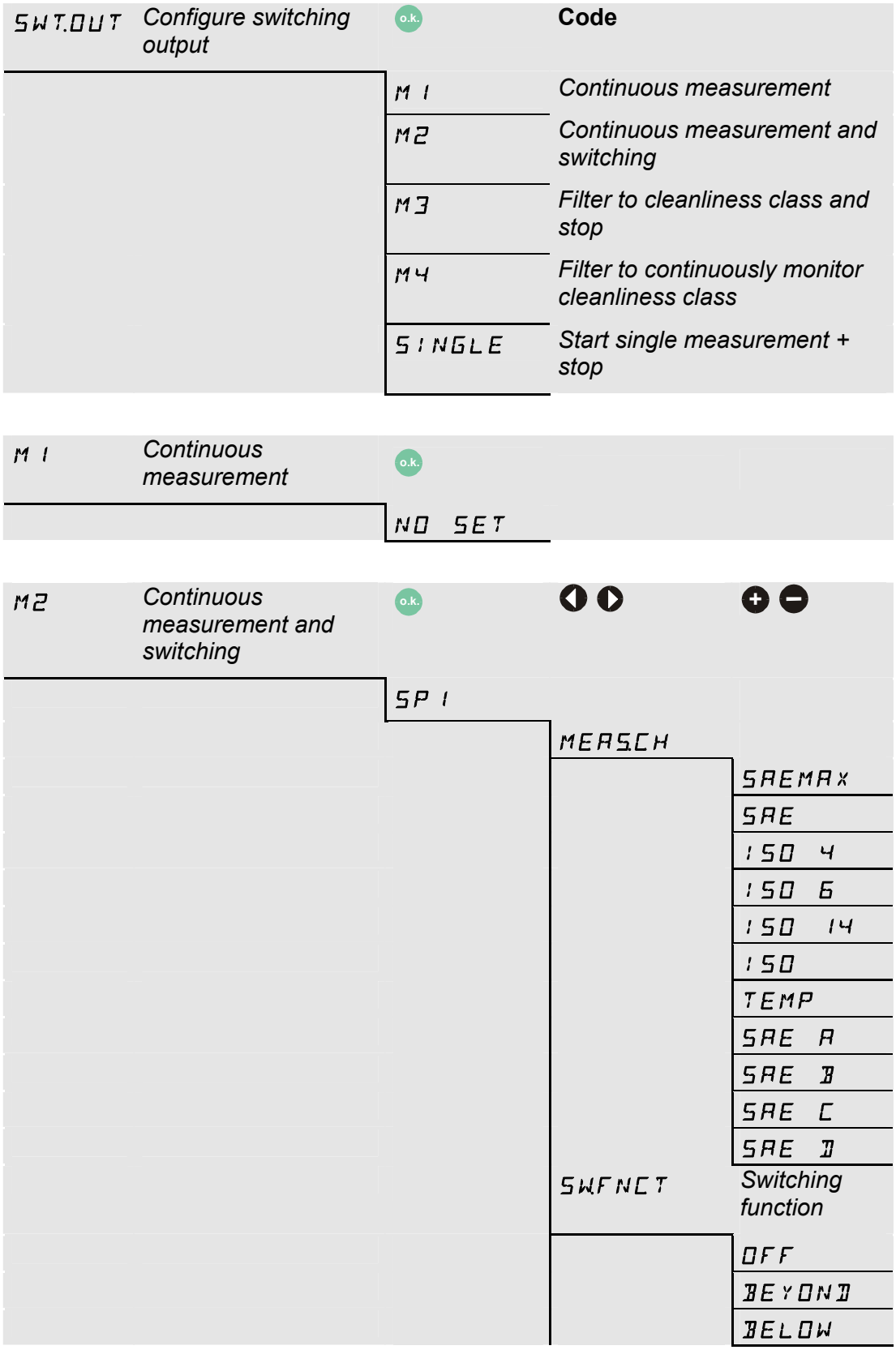
Measuring menu:	◀ ▶	Code
	DISPLAY	*Set display*
	SWT.OUT	*Configure switching output*
	ANAOUT	*Set analog output - output signal*
	CANCEL	*Discard changes and exit*
	SAVE	*Save changes and exit*

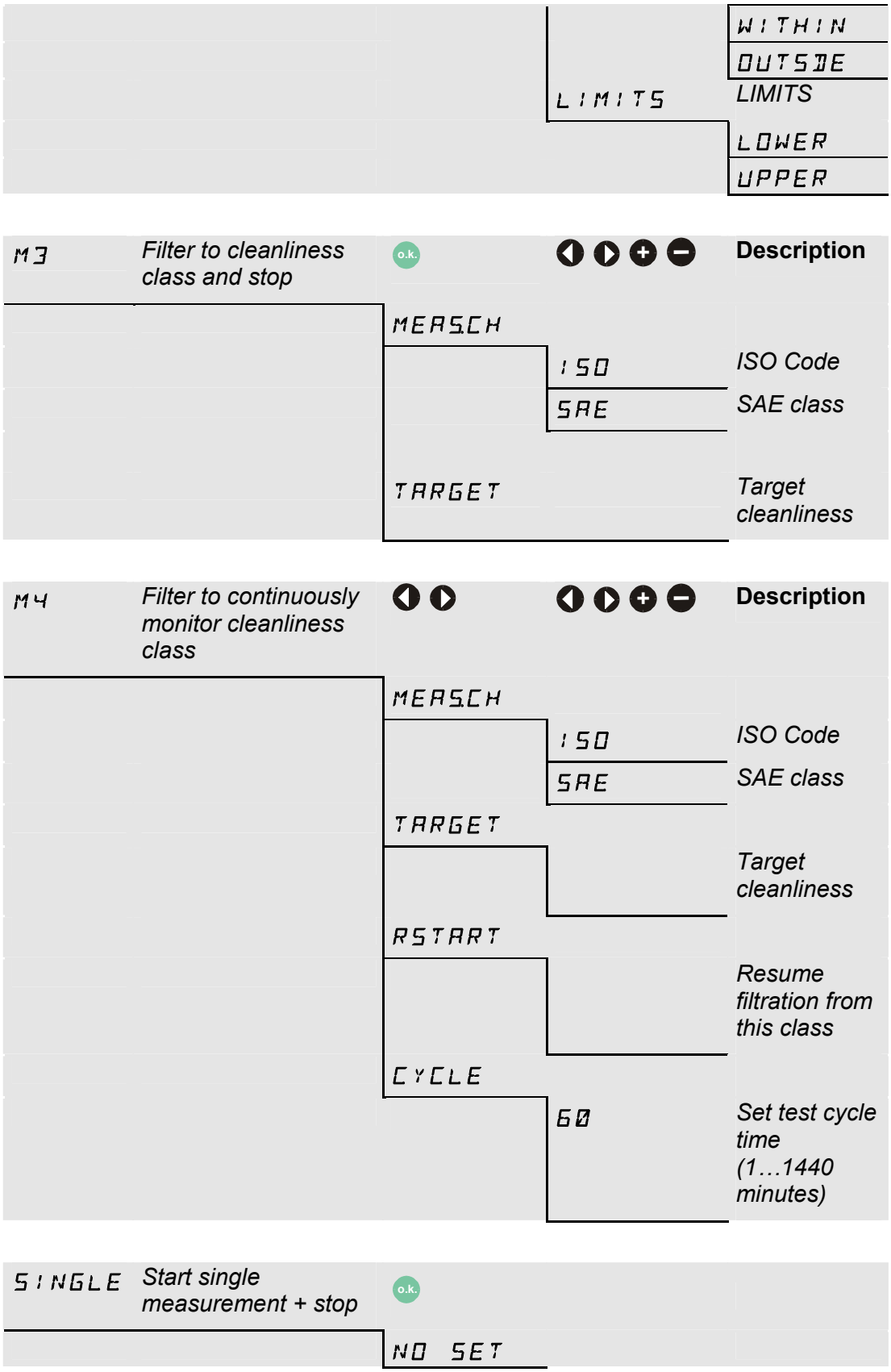
DSPLAY - Display after sensor is switched on

DSPLAY *Set start display*	⊕ ⊖	Code
	ISO	*3-digit ISO code*
	SAE A	*SAE class A*
	SAE B	*SAE class B*
	SAE C	*SAE class C*
	SAE D	*SAE class D*
	SAEMAX	*SAE A-D*
	FLOW	*Flow rate range*
	ANAOUT	*Analog output in mA*
	DRIVE	*LED current in %*
	TEMP C	*Fluid temperature in °C*
	TEMP F	*Fluid temperature in °F*

SWT.OUT – Configure switching output

Here you can adjust the behavior of the switching output. The measurement mode "M1 / M2 / M3 / M4 / SINGLE" is copied from the setting in the PowerUp menu and can no longer be selected here.





ANA.OUT - Set output signal at analog output

The measured variable set here is output at the analog output (see page 55).

ANAOUT	*Set analog output - output signal*	⊕ ⊖	**Code**
		SAEMAx	*SAE A-D*
		SAE	*SAE class A/B/C/D (coded)*
		SAE+T	*SAE class + temp. (Code)*
		TEMP	*Fluid temperature*
		HDA:50	*ISO for HDA 5500*
		HDASAE	*SAE for HDA 5500*
		ISO 4	*ISO 4 code*
		ISO 6	*ISO 6 code*
		ISO 14	*ISO 14 code*
		ISO	*ISO 3-digit (coded)*
		ISO+T	*ISO 3-digit + temp. (coded)*
		SAE A	*SAE class A*
		SAE B	*SAE class B*
		SAE C	*SAE class C*
		SAE D	*SAE class D*

CANCEL	Discard changes and exit

SAVE	Save changes and exit

Measuring menu (CS13xx)

During measurement operation, you can perform the following settings:

Selection	To do
Start Measuring menu	Press the o.k. key.
Scroll to CANCEL and actuate it	Scroll through to CANCEL and press the o.k.-key. If a key is not pressed within 30 seconds, the system jumps back automatically.
Exit menu and save changes	Scroll through to SAVE and press the o.k.-key.

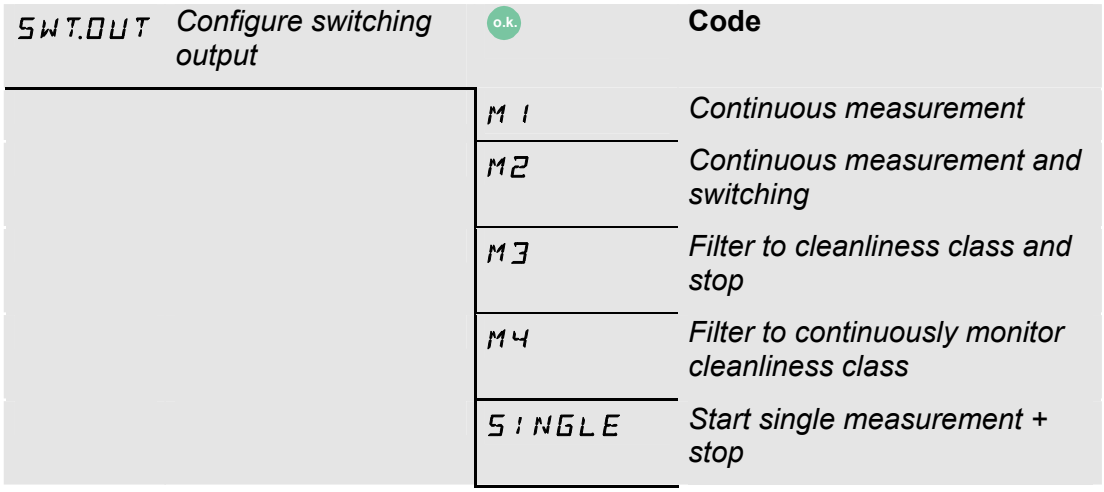
Measuring menu:	◀ ▶	Code
	DISPLAY	*Select display*
	SWT.OUT	*Configure switching output*
	ANAOUT	*Set analog output - output signal*
	CANCEL	*Discard changes and exit*
	SAVE	*Save changes and exit*

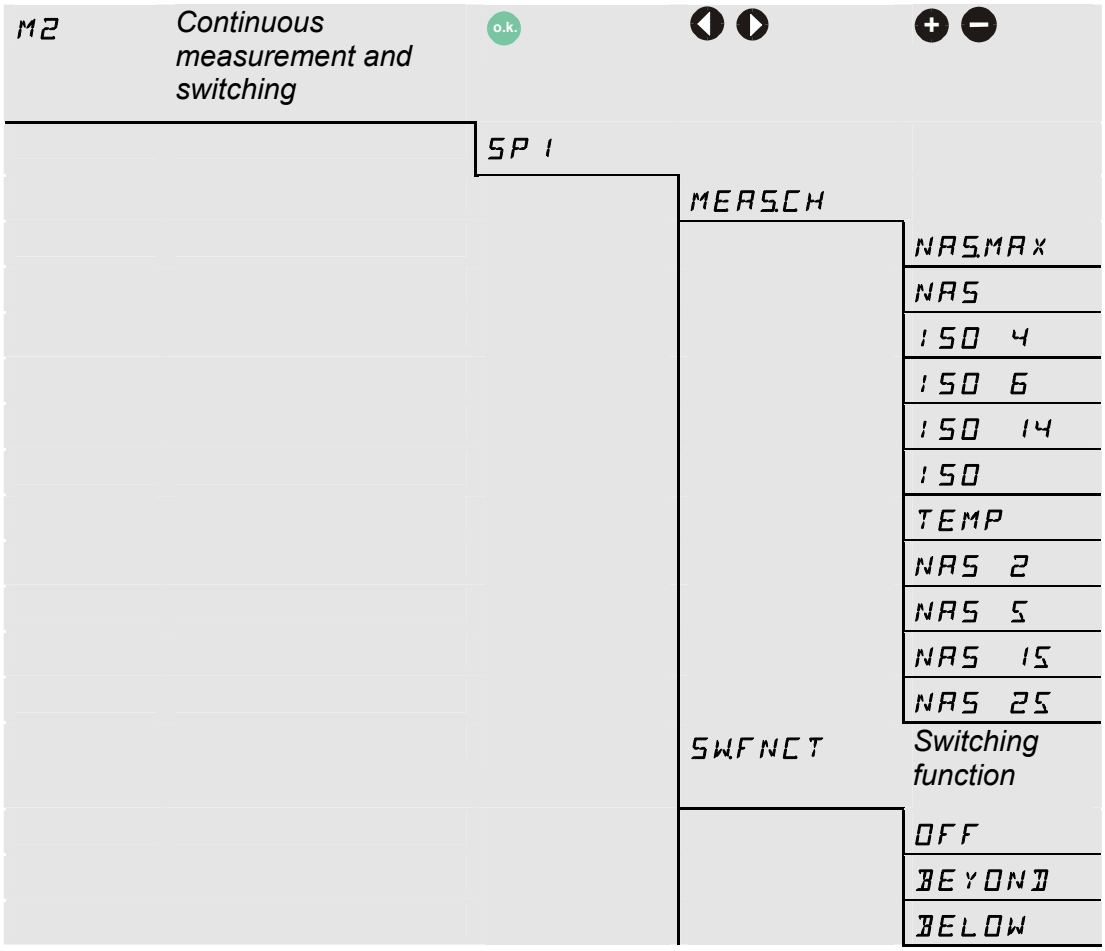
DSPLAY - Display after sensor is switched on

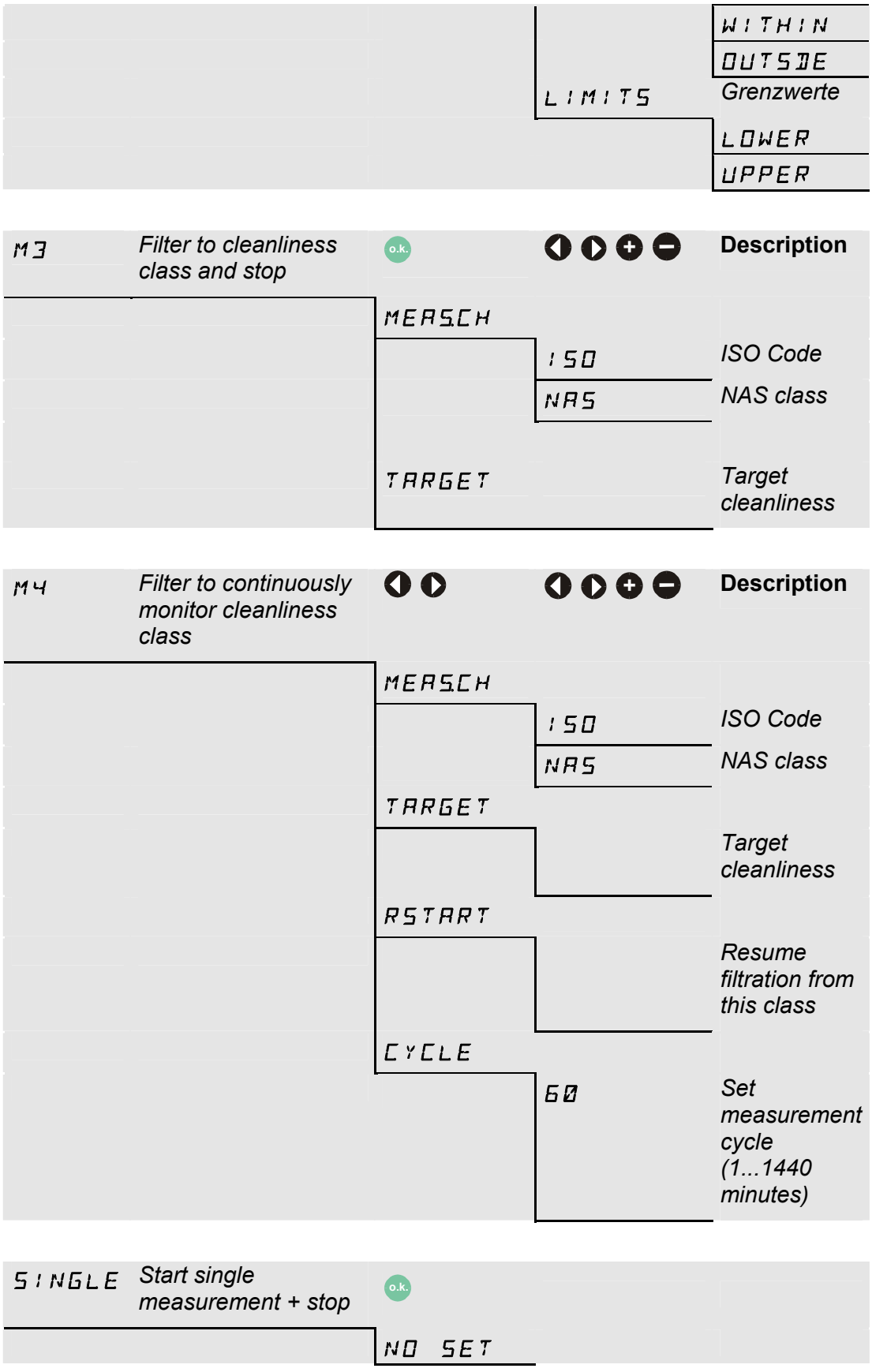
DSPLAY *Set start display*	⊕ ⊖	Code
	ISO	*3-digit ISO code*
	NAS 2	*NAS class 2*
	NAS 5	*NAS class 5*
	NAS 15	*NAS class 15*
	NAS 25	*NAS class 25*
	NASMAX	*NAS maximum*
	FLOW	*Flow rate range*
	ANAOUT	*Analog output in mA*
	DRIVE	*LED current in %*
	TEMP C	*Fluid temperature in °C*
	TEMP F	*Fluid temperature in °F*

SWT.OUT – Configure switching output

Here you can adjust the behavior of the switching output. The measurement mode "M1 / M2 / M3 / M4 / SINGLE" is copied from the setting in the PowerUp menu and can no longer be selected here.






WITHIN
OUTSIDE
LIMITS
Grenzwerte
LOWER
UPPER
M3
Filter to cleanliness class and stop
o.k.
Description
MEASCH
ISO
ISO Code
NAS
NAS class
TARGET
Target cleanliness
M4
Filter to continuously monitor cleanliness class
Description
MEASCH
ISO
ISO Code
NAS
NAS class
TARGET
Target cleanliness
RSTART
Resume filtration from this class
CYCLE
60
Set measurement cycle (1...1440 minutes)
SINGLE
Start single measurement + stop
o.k.
NO SET

ANA.OUT - Set output signal at the analog output

The set measured variable is output via the analog output (see page 55).

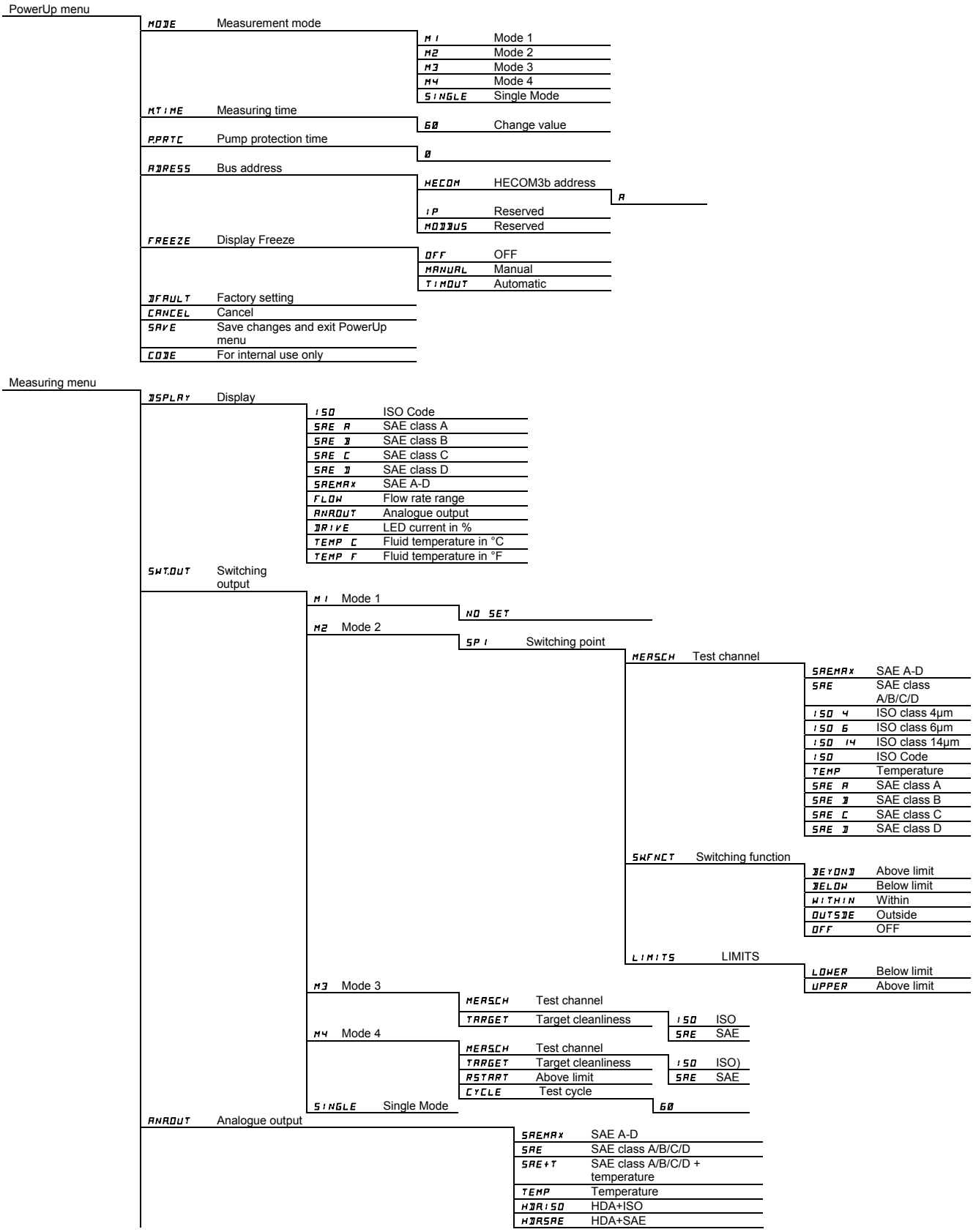
ANAOUT	*Set analog output - output signal*	⊕ ⊖	**Description**
		NAS MAx	*NAS Maximum*
		NAS	*NAS class 2/5/15/25 (coded)*
		NAS+T	*NAS class+temp. (coded)*
		TEMP	*Fluid temperature*
		HDA ISO	*ISO for HDA 5500*
		HDA NAS	*NAS or SAE for HDA 5500*
		ISO 2	*ISO class 2*
		ISO 5	*ISO class 5*
		ISO 15	*ISO class 15*
		ISO	*ISO 3-digit (coded)*
		ISO+T	*ISO 3-digit + temp. (coded)*
		NAS 2	*NAS class 2*
		NAS 5	*NAS class 5*
		NAS 15	*NAS class 15*
		NAS 25	*NAS class 25*

CANCEL	Discard changes and exit

SAVE	Save changes and exit

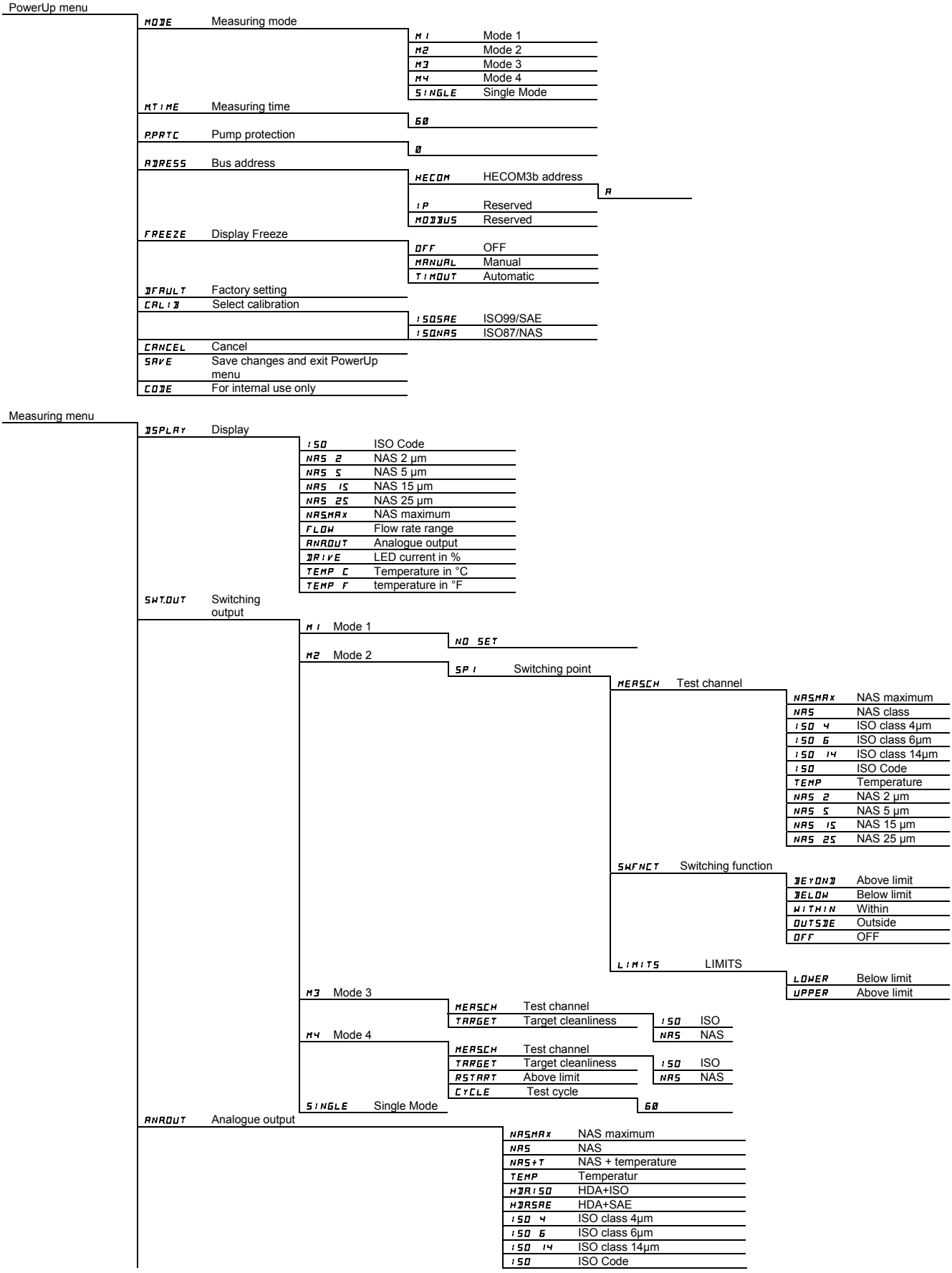
Overview of menu structure

Menu CS 12xx (ISO 4406:1999 and SAE)



		ISO 4	ISO class 4µm
		ISO 6	ISO class 6µm
		ISO 14	ISO class 14µm
		ISO	ISO Code
		ISO+T	ISO code + Temperature
		SAE A	SAE A
		SAE B	SAE B
		SAE C	SAE C
		SAE D	SAE D
CANCEL	Discard changes and exit		
SAVE	Discard changes and exit		

Menu CS 13xx (ISO 4406:1987 and NAS / ISO4406:1999 and SAE 4059 D)



		ISO+T	ISO code + Temperature
		NAS 2	NAS 2 µm
		NAS 5	NAS 5 µm
		NAS 15	NAS 15 µm
		NAS 25	NAS 25 µm
CANCEL	Discard changes and exit		
SAVE	Discard changes and exit		

Using switching output

You can use the switching output in the modes described below. For a further description of the measurement modes, see page 28.

Mode M1: Continuous measurement

Purpose: Measurement only

Function: Continuous measurement of cleanliness class Switching function only for "Device ready".

Mode M2: Continuous measurement and switching

Purpose: Continuous measurement and controlling of signal lamps etc.

Function: Continuous measurement of solid contamination, continuous monitoring of programmed limit values; the switching output is enabled and switches on the monitoring display or alarm on site

Mode M3: Filter to cleanliness class and stop

Purpose: Clean up hydraulic reservoir

Function: Control of a filter unit, continuous measurement of solid contamination. If pre-programmed cleanliness level is reached 5 times in sequence, the pump is stopped.

Mode M4: Filter to continuously monitor cleanliness class

Purpose: Establish continuous monitoring of cleanliness class between min/max limit values

Function: If min/max limit values are pre-programmed, the CS switches the filter unit on/off to keep cleanliness within the limit value range

Load the switching output with a maximum of 2 A and 30 V DC.

Mode "SINGLE" measurement

Purpose: Perform a single measurement and "stop" the result.

Function: Single measurement of solid contamination **without** switching functions Switching function only for "Device ready".

Setting limit values

The voltage supply to the CS1000 makes the switching output (SP1) conductive. This condition is maintained for the initial measurement duration (WAIT period). Depending on the measurement mode, the switching output can be used as a Device ready function.

Mode 1 (M1)	**Switching output – OPEN**	**Switching output – CONDUCTIVE**
	-	Device ready function Conductive, except in the event of an error
Mode 2 (M2)	**Switching output – OPEN**	**Switching output – CONDUCTIVE**
BEYOND Above limit	≥ upper limit	After switch-on or start of a measurement. Becomes conductive again when all values ≤ respective lower limit
BELOW Below limit	≤ lower limit value	After switch-on or start of a measurement. Becomes conductive again when a value ≥ respective upper limit
WITHIN Within limit values	Lower limit ≤ measured value ≤ upper limit	After switch-on or start of a measurement. Becomes conductive again, when a value < respective lower limit or a value > respective upper limit
OUTSIDE Outside limit values	Measured value ≤ lower limit or measured value ≥ upper limit	After switch-on or start of a measurement. Becomes conductive again when the respective lower limit < all values < respective upper limit
OFF OFF	-	Conductive, except in the event of an error
Mode 2 (M2) 3-digit ISO code	**Switching output – OPEN**	**Switching output – CONDUCTIVE**
BEYOND Above limit	A value ≥ upper limit	After switch-on or start of a measurement. Becomes conductive again when all values ≤ respective lower limit
BELOW Below limit	All values ≤ lower limit	After switch-on or start of a measurement. Becomes conductive again when a value ≥ respective upper limit

WITHIN Within limit values	Lower limit ≤ all values ≤ upper limit	After switch-on or start of a measurement. Becomes conductive again, when a value < respective lower limit or a value > respective upper limit
OUTSIDE Outside limit values	A value ≤ lower limit or A value ≥ upper limit	After switch-on or start of a measurement. Becomes conductive again when the respective lower limit < all values < respective upper limit
OFF No switching function	-	Conductive, except in the event of an error
Mode 3 (M3)	**Switching output – OPEN**	**Switching output – CONDUCTIVE**
	5 consecutive measurements ≤ limit or measurement stopped	Measurement is currently in progress and one or more of the last 5 measured values > limit
Mode 4 (M4)	**Switching output – OPEN**	**Switching output – CONDUCTIVE**
Start or result of check measurement after test cycle time: a value ≥ upper limit	For 5 consecutive measurements: all values ≤ lower limit or measurement stopped	Measurement is in progress and during one or more of the last 5 measurements: a value > lower limit
Upon the test cycle time elapsing for the duration of a check measurement	Is open again when all values < upper limit Restart test cycle time	Test cycle time has elapsed
Single Mode SINGLE	**Switching output – OPEN**	**Switching output – CONDUCTIVE**
	-	Device ready function Always CONDUCTIVE except in the event of an error

Reading the analog output

Depending on CS model, the analog output is available as a 4 ... 20 mA or 2 ... 10 V signal.

You can recognize the type of analog output from the model code of the sensor.

CS Model code	Analogue output
CS 1 x x x - **A** – x – x – x – x /-xxx	4 … 20 mA
CS 1 x x x - **B** – x – x – x – x /-xxx	2 … 10 V

Observe the design of the analog output in the order. It is not possible to internally change the analog output over later.

In the measuring menu, select one of the following signals for the analog output:

- SAE classes acc. to AS 4059
- ISO Code acc. to 4406:1999
- ISO Code acc. to 4406:1987
- NAS class 1638
- Hydraulic fluid temperature

SAE classes acc. to AS 4059

The following SAE values can be read out via the analog output:

- **SAE A-D (SAEMAX)**

  Only one single value is output.

- **SAE A / B / C / D**

  All values are sequentially time-coded before output.

- **SAE A / SAE B / SAE C / SAE D**

  Only one value is output.

- **SAE+T**

  All values are sequentially time-coded before output.

- **HDA.SAE**

  All values are sequentially time-coded before output.
  This signal is planned for the HDA 5500, but it can be used also in other applications.

The current 4.8 … 19.2 mA or voltage 2.4 … 9.6 V of the output signal is dependent on the ISO contamination class SAE = 0.0 … 14.0 (resolution 0.1 class) or an error as shown in the table below:

Current I =	SAE class / Error	Voltage U =
I < 4,00 mA	Cable break	U < 2,00 V
4.0 mA < I < 4.1 mA	Device error, device not ready	2,00 V < U < 2,05 V
4,1 mA < I < 4,3 mA	Not defined	2,05 V < U < 2,15 V
4,3 mA < I < 4,5 mA	Flow error (The flow rate is too low.)	2,15 V < U < 2,25 V
4,5 mA < I < 4,8 mA	Not defined	2,25 V < U < 2,40 V
I = 4,80 mA	SAE 0	U = 2,4 V
I = 4,90 mA	SAE 0,1	U = 2,45 V
I = 5,01 mA	SAE 0,2	U = 2,51 V
…	…	…
I = 5,83 mA	SAE 1	U = 2,92 V
I = 6,86 mA	SAE 2	U = 3,43 V
I = 7,89 mA	SAE 3	U = 3,95 V
I = 8,91 mA	SAE 4	U = 4,46 V
I = 9,94 mA	SAE 5	U = 4,97 V
I = 10,97 mA	SAE 6	U = 5,49 V
I = 12,00 mA	SAE 7	U = 6,00 V
I = 13,03 mA	SAE 8	U = 6,52 V
I = 14,06 mA	SAE 9	U = 7,03 V
I = 15,09 mA	SAE 10	U = 7,55 V
I = 16,11 mA	SAE 11	U = 8,06 V
I = 17,14 mA	SAE 12	U = 8,57 V
I = 18,17 mA	SAE 13	U = 9,09 V

Current I =	SAE class / Error	Voltage U =
…	…	…
I = 18,99 mA	SAE 13,8	U = 9,50 V
I = 19,10 mA	SAE 13,9	U = 9,55 V
I = 19,20 mA	SAE 14,0	U = 9,60 V
19,2 mA < I < 19,8 mA	Not defined	9,60 V < U < 9,90 V
19,8 mA < I < 20 mA	No measured value	9,90 V < U < 10 V

If the contamination class is given acc. to SAE, the current I or voltage U can be calculated:

I = 4.8 mA + SAE class x (19.2 mA - 4.8 mA) / 14

U = 2.4 V + SAE class x (9.6 V - 2.4 V) / 14

If the contamination class is given acc. to SAE, the current I or voltage U can be calculated:

SAE class = (I - 4.8 mA) x (14/14.4 mA)

SAE class = (U - 2.4 V) x (14/7.2 V)

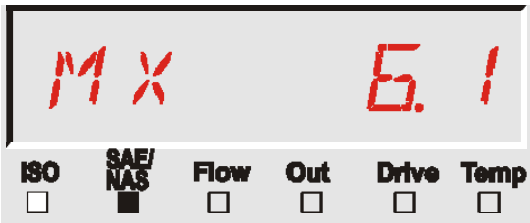
SAE A-D

The **SAeMAX** value is the highest class in any of one of the four SAE A-D classes (respectively >4 $\mu m_{(c)}$,>6 $\mu m_{(c)}$,>14 $\mu m_{(c)}$,>21 $\mu m_{(c)}$).

The signal is updated after the measuring period has elapsed (the measuring period is set in the PowerUp menu, factory setting = 60 s).

The SAEMAX signal is output depending on the maximum SAE class.

Example:

SAE classes	SAEMAX (SAE A-D)
SAE 6.1A / 5.7B / 6.0C / 5.5D	

For basic information about cleanliness classes, see page 96 ff.

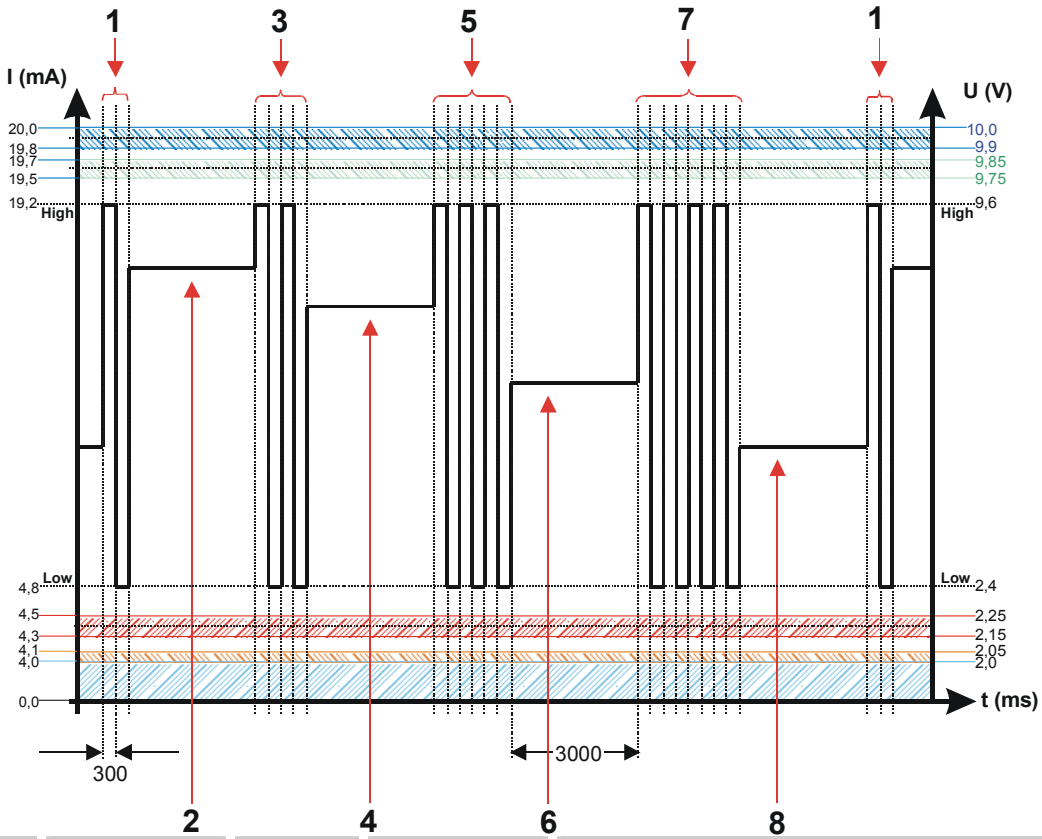
The SAE classification contains integer values only. Better change / trend recognition is based on a resolution of 0.1 contamination classes.

To convert a decimal value to an integer, the decimal value has to be rounded up.

For example: a readout of SAE 10.7 is, according to SAE 4059 (D), a class SAE 11.

SAE Class A / B / C / D

The SAE class A/B/C/D signal consists of 4 measured values transmitted with the following time-coded time slices:



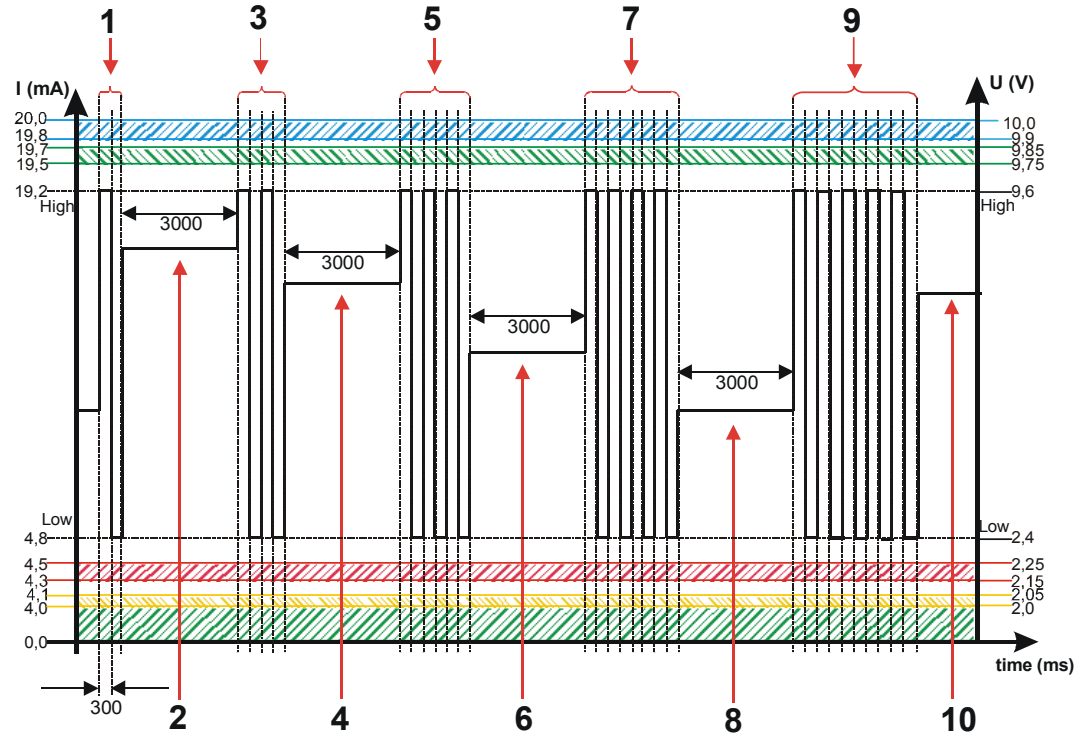
Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	SAE A	300	High / Low
	2	Measured value	SAE A	3000	Current/Voltage for measured value
	3	Identifier	SAE B	300	High / Low / High / Low
	4	Measured value	SAE B	3000	Current/Voltage for measured value
	5	Identifier	SAE C	300	High / Low / High / Low / High / Low
	6	Measured value	SAE C	3000	Current/Voltage for measured value
	7	Identifier	SAE D	300	High / Low / High / Low / High / Low / High / Low
	8	Measured value	SAE D	3000	Current/Voltage for measured value

SAE A / SAE B / SAE C / SAE D

The SAE x setting enables the value of a class to be continuously output via the analog output.

SAE + T

The SAE+T signal consists of 5 measured values which are transmitted time-coded with the following time slices:

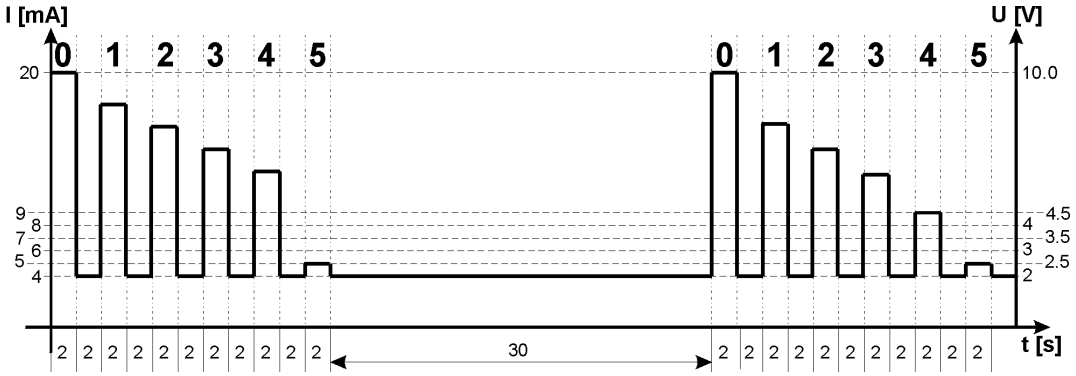


Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	SAE A	300	High / Low
	2	Measured value	SAE A	3000	Current/Voltage for measured value
	3	Identifier	SAE B	300	High / Low / High / Low
	4	Measured value	SAE B	3000	Current/Voltage for measured value
	5	Identifier	SAE C	300	High / Low / High / Low / High / Low
	6	Measured value	SAE C	3000	Current/Voltage for measured value
	7	Identifier	SAE D	300	High / Low / High / Low / High / Low / High / Low
	8	Measured value	SAE D	3000	Current/Voltage for measured value
	9	Identifier	Temperature	300	High / Low / High / Low / High / Low / High / Low / High / Low
	10	Measured value	Temperature	3000	Current/Voltage for measured value

HDA.SAE – Analog signal SAE to the HDA 5500

The HDA.SAE signal consists of 6 values (START / SAE A / SAE B / SAE C / SAE D / Status) which are output sequentially. Synchronization with the downstream control unit is a prerequisite.

The signal output is as follows:



Time		Measured variable	Signal duration in s	Current/Voltage
	Start signal 0	--	2	20 mA / 10 V
	Pause		2	4 mA / 2 V
	Signal 1	SAE A	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 2	SAE B	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 3	SAE C	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 4	SAE D	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 5	Status	2	Current / Voltage for signal
	Pause		30	4 mA / 2 V

HDA.SAE Signal 1/2/3/4

The current or voltage range is dependent on the contamination class according to SAE=0.0 – 14.0 (resolution 0.1 class).

Current I =	SAE class / Error	Voltage U =
I< 4,00 mA	Cable break	U< 2,00 V
I = 4,00 mA	SAE 0	U = 2,00 V
I = 4,11 mA	SAE 0,1	U = 2,06 V
I = 4,23 mA	SAE 0,2	U = 2,11 V
…	…	…
I = 5,14 mA	SAE 1	U = 2,57 V
I = 6,29 mA	SAE 2	U = 3,14 V
I = 7,43 mA	SAE 3	U = 3,71 V
I = 8,57 mA	SAE 4	U = 4,29 V
I = 9,71 mA	SAE 5	U = 4,86 V
I = 10,86 mA	SAE 6	U = 5,43 V
I = 12,00 mA	SAE 7	U = 6,00 V
I = 13,14 mA	SAE 8	U = 6,57 V
I = 14,29 mA	SAE 9	U = 7,14 V
I = 15,43 mA	SAE 10	U = 7,71 V
I = 16,57 mA	SAE 11	U = 8,29 V
I = 17,71 mA	SAE 12	U = 8,86 V
I = 18,86 mA	SAE 13	U = 9,43 V
…	…	…
I = 19,77 mA	SAE 13,8	U = 9,89 V
I = 19,89 mA	SAE 13,9	U = 9,94 V
I = 20,00 mA	SAE 14,0	U = 10,00 V

If the contamination class is given acc. to SAE, the current I or voltage U can be calculated:

I = 4 mA + SAE class x (20 mA - 4 mA) / 14

U = 2 V + SAE class x (10 V - 2 V) / 14

If the contamination class is given acc. to SAE, the current I or voltage U can be calculated:

SAE class = (I - 4 mA) x (14/16 mA)

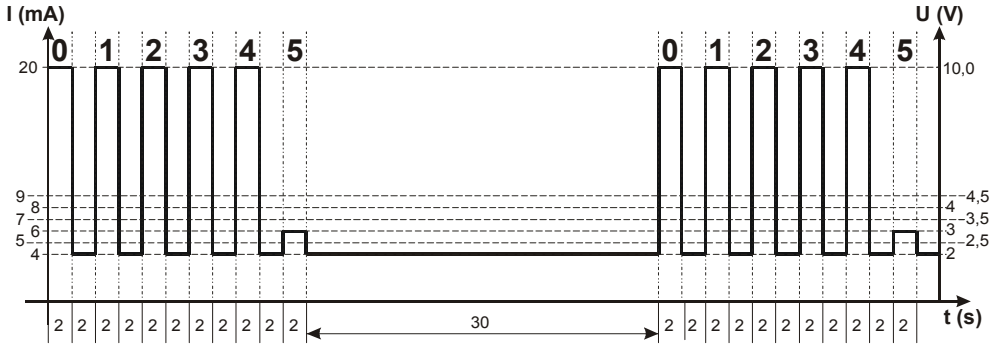
SAE class = (U - 2 V) x (14/8 V)

HDA.SAE Status Signal 5 (Status)

The current or voltage of the output signal (5) is dependent on the status of the CS1000 as shown in the table below:

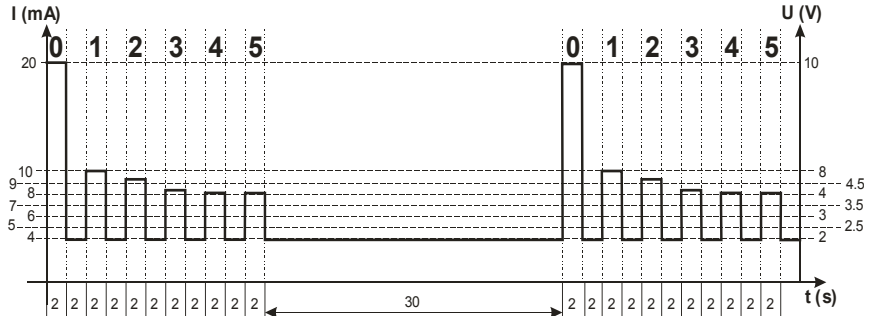
Current I =	Status	Voltage U =
I = 5,0 mA	The CS is functioning correctly.	U = 2,5 V
I = 6.0 mA	Device error / The CS is not ready.	U = 3,0 V
I = 7,0 mA	The flow rate is too low.	U = 3,5 V
I = 8,0 mA	SAE < 0	U = 4,0 V
I = 9,0 mA	No measured value (The flow rate is not defined.)	U = 4,5 V

If the status signal is 6.0 / 7.0 / 9.0 mA or 3.0 / 3.5 / 4.5 V, signals 1 to 4 are output with 20 mA or 10 V. Example:



If the status signal is 8.0 mA or 4.0 V, signals 1 to 4 are output as follows.

Signal	mA	V
1	10	5.0
2	9.2	4.6
3	8.6	4.3
4	8.0	4.0



ISO Code as per 4406:1999

The following ISO values can be read out via the analog output:

- **ISO 4 / ISO 6 / ISO 14**

  Only one value is output.

- **ISO code in 3 figures (>4µm$_{(c)}$ / >6µm$_{(c)}$ / >14µm$_{(c)}$)**

  All values are sequentially time-coded before output.

- **ISO+T**

  All values are sequentially time-coded before output.

- **HDA.ISO**

  All values are sequentially time-coded before output.
  This signal is planned for the HDA 5500, but it can be used also in other applications.

The current 4.8 … 19.2 mA or voltage 2.4 … 9.6 V of the output signal is dependent on the ISO contamination class 0.0 … 24.28 (resolution 1 class) or an error as shown in the table below:

Current I =	ISO code / error	Voltage U =
I< 4,0 mA	Cable break	U< 2,0 V
4,0 mA < I < 4,1 mA	Device error, device not ready	2,0 V < U < 2,05 V
4,1 mA < I < 4,3 mA	Not defined	2,05 V < U < 2,15 V
4,3 mA < I < 4,5 mA	Flow error (The flow rate is too low.)	2,15 V < U < 2,25 V
4,5 mA < I < 4,8 mA	Not defined	2,25 V < U < 2,4 V
I = 4,80 mA	ISO 0	U = 2,40 V
I = 5,37 mA	ISO 1	U = 2,69 V
I = 5,94 mA	ISO 2	U = 2,97 V
I = 6,51 mA	ISO 3	U = 3,26 V
I = 7,08 mA	ISO 4	U = 3,54 V
I = 7,65 mA	ISO 5	U = 3,83 V
I = 8,22 mA	ISO 6	U = 4,11 V
I = 8,79 mA	ISO 7	U = 4,40 V
I = 9,36 mA	ISO 8	U = 4,68 V
I = 9,93 mA	ISO 9	U = 4,97 V
I = 10,50 mA	ISO 10	U = 5,25 V
I = 11,07 mA	ISO 11	U = 5,54 V
I = 11,64 mA	ISO 12	U = 5,82 V
I = 12,21 mA	ISO 13	U = 6,11 V
I = 12,77 mA	ISO 14	U = 6,39 V
I = 13,34 mA	ISO 15	U = 6,67 V
I = 13,91 mA	ISO 16	U = 6,96 V
I = 14,48 mA	ISO 17	U = 7,24 V
I = 15,05 mA	ISO 18	U = 7,53 V

Current I =	ISO code / error	Voltage U =
I = 15,62 mA	ISO 19	U = 7,81 V
I = 16,19 mA	ISO 20	U = 8,10 V
I = 16,76 mA	ISO 21	U = 8,38 V
I = 17,33 mA	ISO 22	U = 8,67 V
I = 17,90 mA	ISO 23	U = 8,95 V
I = 18,47 mA	ISO 24	U = 9,24 V
I = 19,20 mA	ISO 24,28	U = 9,60 V
19,2 mA < I < 19,8 mA	Not defined	9,60 V < U < 9,90 V
19,8 mA < I < 20 mA	No measured value	9,90 V < U < 10 V

The current (I) or voltage (U) can be calculated for a given ISO contamination class as follows:

I = 4.8 mA + ISO code x (19.2 mA - 4.8 mA) / 24.28

U = 2.4 V + ISO Code x (9.6 V - 2.4 V) / 24.28

The ISO contamination class can be calculated for a given current I or voltage U as follows:

ISO code = (I - 4.8 mA) x (24.28 / 14.4 mA)

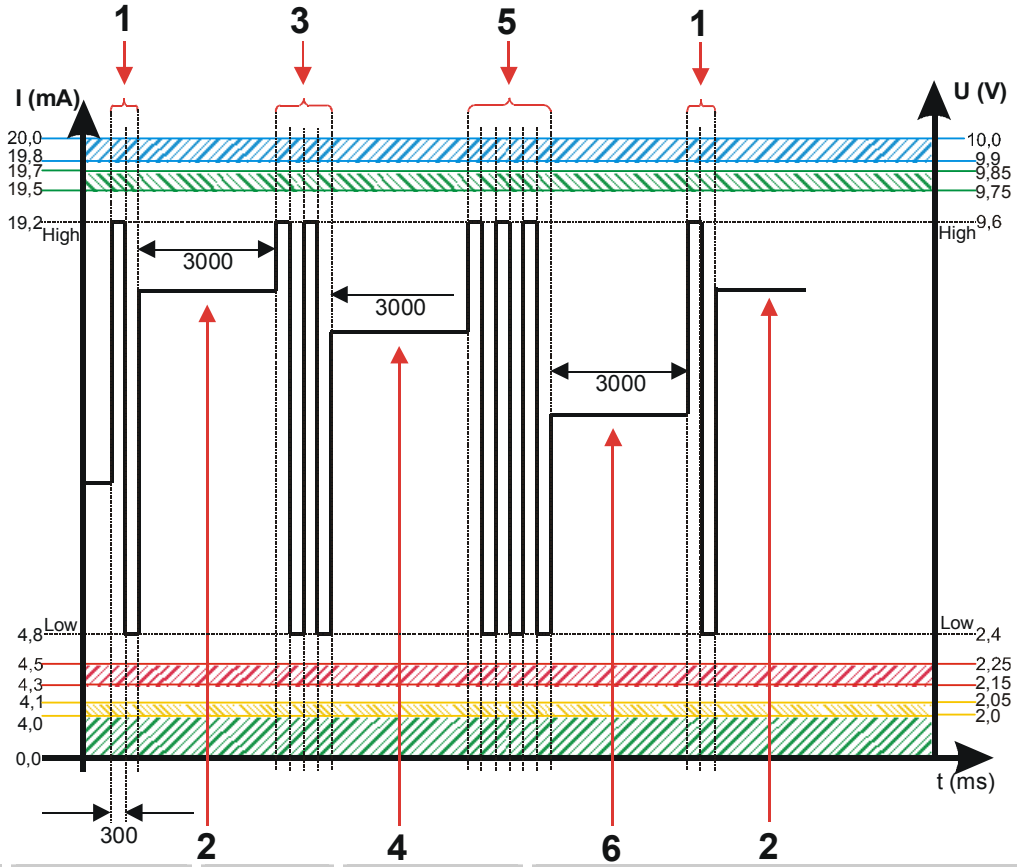
ISO code = (U - 2.4 V) x (24.28 / 7.2 V)

ISO 4 / ISO 6 / ISO 14

The ISO x setting enables the value of a class to be continuously output via the analog output.

ISO code, 3-digit

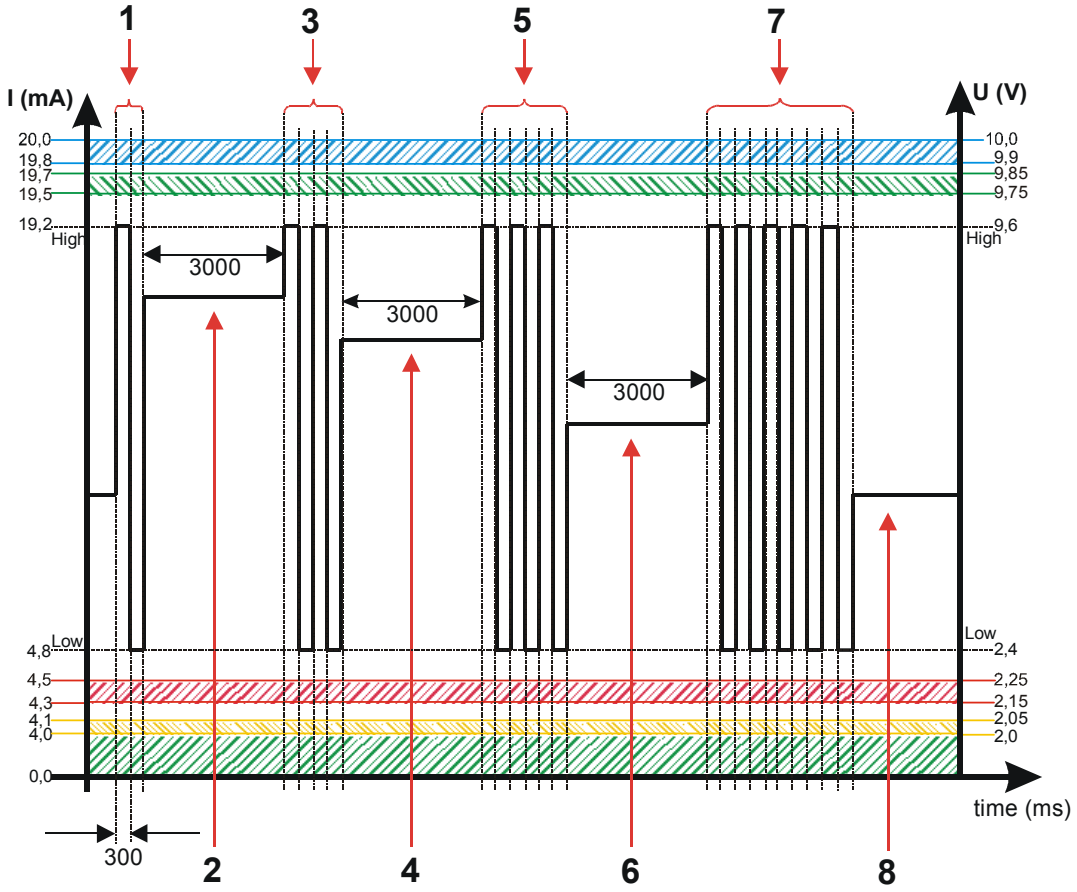
The ISO code signal consists of 3 measured values (>4µm$_{(c)}$ / >6µm$_{(c)}$ / >14µm$_{(c)}$) which are transmitted time-coded.



Time			Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	>4µm$_{(c)}$	300	High / Low
	2	Measured value	>4µm$_{(c)}$	3000	Current/Voltage for measured value
	3	Identifier	>6µm$_{(c)}$	300	High / Low / High / Low
	4	Measured value	>6µm$_{(c)}$	3000	Current/Voltage for measured value
	5	Identifier	>14µm$_{(c)}$	300	High / Low / High / Low / High / Low
	6	Measured value	>14µm$_{(c)}$	3000	Current/Voltage for measured value

ISO + T

The ISO+T signal consists of 4 measured values which are transmitted time-coded with the following time slices:

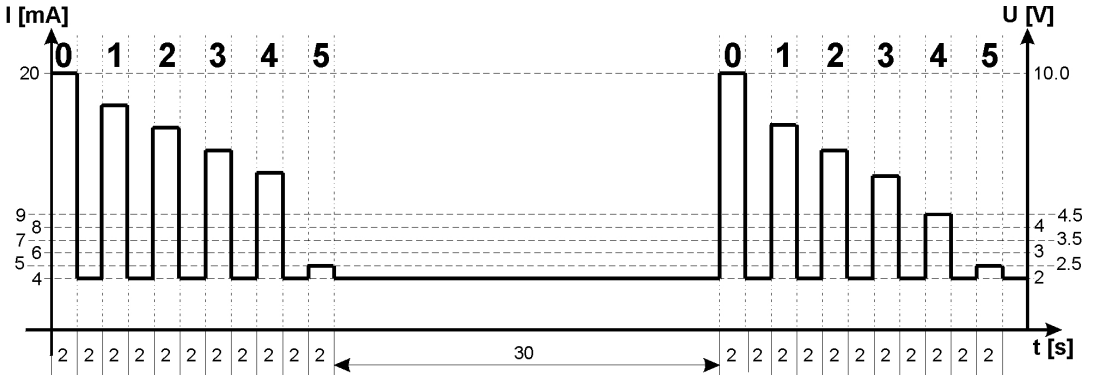


Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	>4µm$_{(c)}$	300	High / Low
	2	Measured value	>4µm$_{(c)}$	3000	Current/Voltage for measured value
	3	Identifier	>6µm$_{(c)}$	300	High / Low / High / Low
	4	Measured value	>6µm$_{(c)}$	3000	Current/Voltage for measured value
	5	Identifier	>14µm$_{(c)}$	300	High / Low / High / Low / High / Low
	6	Measured value	>14µm$_{(c)}$	3000	Current/Voltage for measured value
	7	Identifier	Temperature	300	High / Low / High / Low / High / Low / High / Low / High / Low
	8	Measured value	Temperature	3000	Current/Voltage for measured value

HDA.ISO – Analog signal ISO to HDA 5500

The HDA.ISO signal consists of 6 measured values (START / ISO 4 / ISO 6 / ISO 14 / ISO 21 / Status) which are output sequentially. Synchronization with the downstream control unit is a prerequisite.

The signal output is as follows:



Time		Measured variable	Signal duration in s	Current/Voltage
	Start signal 0	--	2	20 mA / 10 V
	Pause		2	4 mA / 2 V
	Signal 1	ISO 4	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 2	ISO 6	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 3	ISO 14	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 4	ISO 21	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 5	Status	2	Current / Voltage for signal
	Pause		30	4 mA / 2 V

HDA.ISO Signal 1/2/3/4

The current 4 … 20 mA or voltage 2 … 10 V of the output signal is dependent on the ISO contamination class 0.0 … 24.4 (resolution 1 class) as shown in the table below:

Current I =	ISO Code	Voltage U =
I < 4,00 mA	Cable break	U < 2,00 V
I = 4,00 mA	ISO 0	U = 2,00 V
I = 4,39 mA	ISO 1	U = 2,20 V
I = 5,20 mA	ISO 2	U = 2,60 V
I = 5,92 mA	ISO 3	U = 2,96 V
I = 6,61 mA	ISO 4	U = 3,30 V
I = 7,28 mA	ISO 5	U = 3,64 V
I = 7,95 mA	ISO 6	U = 3,97 V
I = 8,63 mA	ISO 7	U = 4,18 V
I = 9,25 mA	ISO 8	U = 4,62 V
I = 9,91 mA	ISO 9	U = 4,95 V
I = 10,57 mA	ISO 10	U = 5,28 V
I = 11,23 mA	ISO 11	U = 5,61 V
I = 11,89 mA	ISO 12	U = 5,94 V
I = 12,55 mA	ISO 13	U = 6,27 V
I = 13,20 mA	ISO 14	U = 6,60 V
I = 13,86 mA	ISO 15	U = 6,93 V
I = 14,52 mA	ISO 16	U = 7,26 V
I = 15,20 mA	ISO 17	U = 7,60 V
I = 15,82 mA	ISO 18	U = 7,91V
I = 16,48 mA	ISO 19	U = 8,24 V
I = 17,13 mA	ISO 20	U = 8,56 V
I = 17,79 mA	ISO 21	U = 8,90 V
I = 18,45 mA	ISO 22	U = 8,23 V
I = 19,11 mA	ISO 23	U = 9,56 V
I = 19,82 mA	ISO 24	U = 9,90 V
I = 20,00 mA	ISO 24,28	U = 10,0 V

The current (I) or voltage (U) can be calculated for a given ISO contamination class as follows:

I = 4 mA + ISO code x (20 mA - 4 mA) / 24.28

U = 2 V + ISO Code x (10 V - 2 V) / 24.28

The ISO contamination class can be calculated for a given current I or voltage U as follows:

ISO code = (I - 4 mA) x (24.28 / 16 mA)

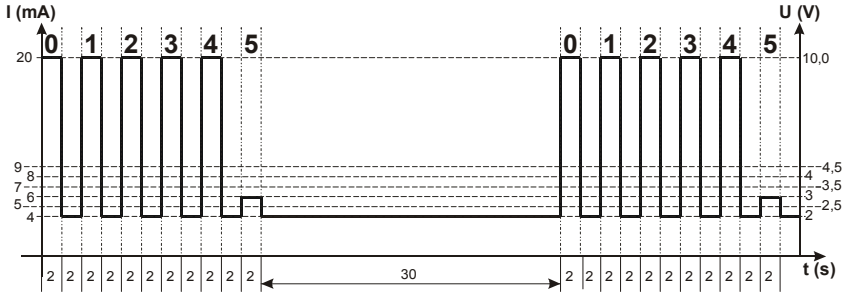
ISO code = (U - 2 V) x (24.28 / 8 V)

HDA.ISO Status Signal 5 (Status)

The current or voltage of the output signal (5) is dependent on the status of the CS1000 as shown in the table below:

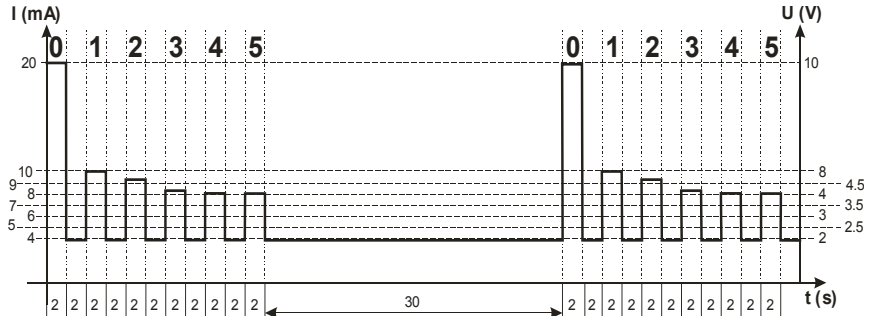
Current I =	Status	Voltage U =
I = 5,0 mA	The CS is functioning correctly.	U = 2,5 V
I = 6,0 mA	Device error / The CS is not ready.	U = 3,0 V
I = 7,0 mA	The flow rate is too low.	U = 3,5 V
I = 8,0 mA	ISO <9.<8.<7	U = 4,0 V
I = 9,0 mA	No measured value (The flow rate is not defined.)	U = 4,5 V

If the status signal is 6.0 / 7.0 / 9.0 mA or 3.0 / 3.5 / 4.5 V, signals 1 to 4 are output with 20 mA or 10 V. Example:



If the status signal is 8.0 mA or 4.0 V, signals 1 to 4 are output as follows.

Signal	mA	V
1	10	5.0
2	9.2	4.6
3	8.6	4.3
4	8.0	4.0



ISO code signal acc. to 4406:1987 (CS 13xx only)

The following ISO values can be read out via the analog output:

- **ISO 2 / ISO 5 / ISO 15**

  Only one value is output.

- **ISO code in 3 figures (>2µm$_{(c)}$ / >5µm$_{(c)}$ / >15µm$_{(c)}$)**

  All values are sequentially time-coded before output.

- **ISO+T**

  All values are sequentially time-coded before output.

- **HDA.ISO**

  All values are sequentially time-coded before output.
  This signal is planned for the HDA 5500, but it can be used also in other applications.

The current 4.8 … 19.2 mA or voltage 2.4 … 9.6 V of the output signal is dependent on the ISO contamination class 0.0 … 24.28 (resolution 1 class) or an error as shown in the table below:

Current I =	ISO code / error	Voltage U =
I < 4,00 mA	Cable break	U < 2,00 V
4,0 mA < I < 4,1 mA	Device error, device not ready	2,0 V < U < 2,05 V
4,1 mA < I < 4,3 mA	Not defined	2,05 V < U < 2,15 V
4,3 mA < I < 4,5 mA	Flow error (The flow rate is too low.)	2,15 V < U < 2,25 V
4,5 mA < I < 4,8 mA	Not defined	2,25 V < U < 2,4 V
I = 4,80 mA	ISO 0	U = 2,40 V
I = 5,37 mA	ISO 1	U = 2,69 V
I = 5,94 mA	ISO 2	U = 2,97 V
I = 6,51 mA	ISO 3	U = 3,26 V
I = 7,08 mA	ISO 4	U = 3,54 V
I = 7,65 mA	ISO 5	U = 3,83 V
I = 8,22 mA	ISO 6	U = 4,11 V
I = 8,79 mA	ISO 7	U = 4,40 V
I = 9,36 mA	ISO 8	U = 4,68 V
I = 9,93 mA	ISO 9	U = 4,97 V
I = 10,50 mA	ISO 10	U = 5,25 V
I = 11,07 mA	ISO 11	U = 5,54 V
I = 11,64 mA	ISO 12	U = 5,82 V
I = 12,21 mA	ISO 13	U = 6,11 V
I = 12,77 mA	ISO 14	U = 6,39 V
I = 13,34 mA	ISO 15	U = 6,67 V
I = 13,91 mA	ISO 16	U = 6,96 V
I = 14,48 mA	ISO 17	U = 7,24 V
I = 15,05 mA	ISO 18	U = 7,53 V

Current I =	ISO code / error	Voltage U =
I = 15,62 mA	ISO 19	U = 7,81 V
I = 16,19 mA	ISO 20	U = 8,10 V
I = 16,76 mA	ISO 21	U = 8,38 V
I = 17,33 mA	ISO 22	U = 8,67 V
I = 17,90 mA	ISO 23	U = 8,95 V
I = 18,47 mA	ISO 24	U = 9,24 V
I = 19,20 mA	ISO 24,28	U = 9,60 V
19,2 mA < I < 19,8 mA	Not defined	9,60 V < U < 9,90 V
19,8 mA < I < 20 mA	No measured value	9,90 V < U < 10 V

The current (I) or voltage (U) can be calculated for a given ISO contamination class as follows:

I = 4.8 mA + ISO code x (19.2 mA - 4.8 mA) / 24.28

U = 2.4 V + ISO Code x (9.6 V - 2.4 V) / 24.28

The ISO contamination class can be calculated for a given current I or voltage U as follows:

ISO code = (I - 4.8 mA) x (24.28 / 14.4 mA)

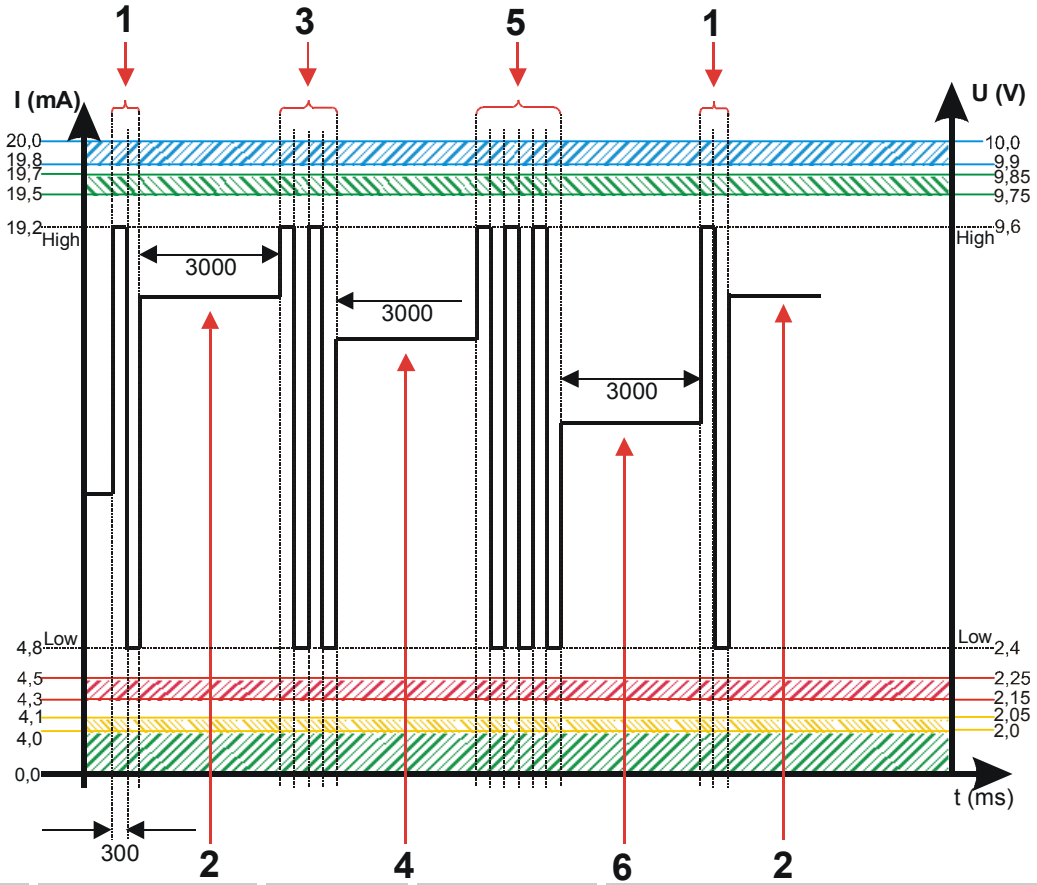
ISO code = (U - 2.4 V) x (24.28 / 7.2 V)

ISO 2 / ISO 5 / ISO 15

The ISO x setting enables the value of a class to be continuously output via the analog output.

ISO code, 3-digit

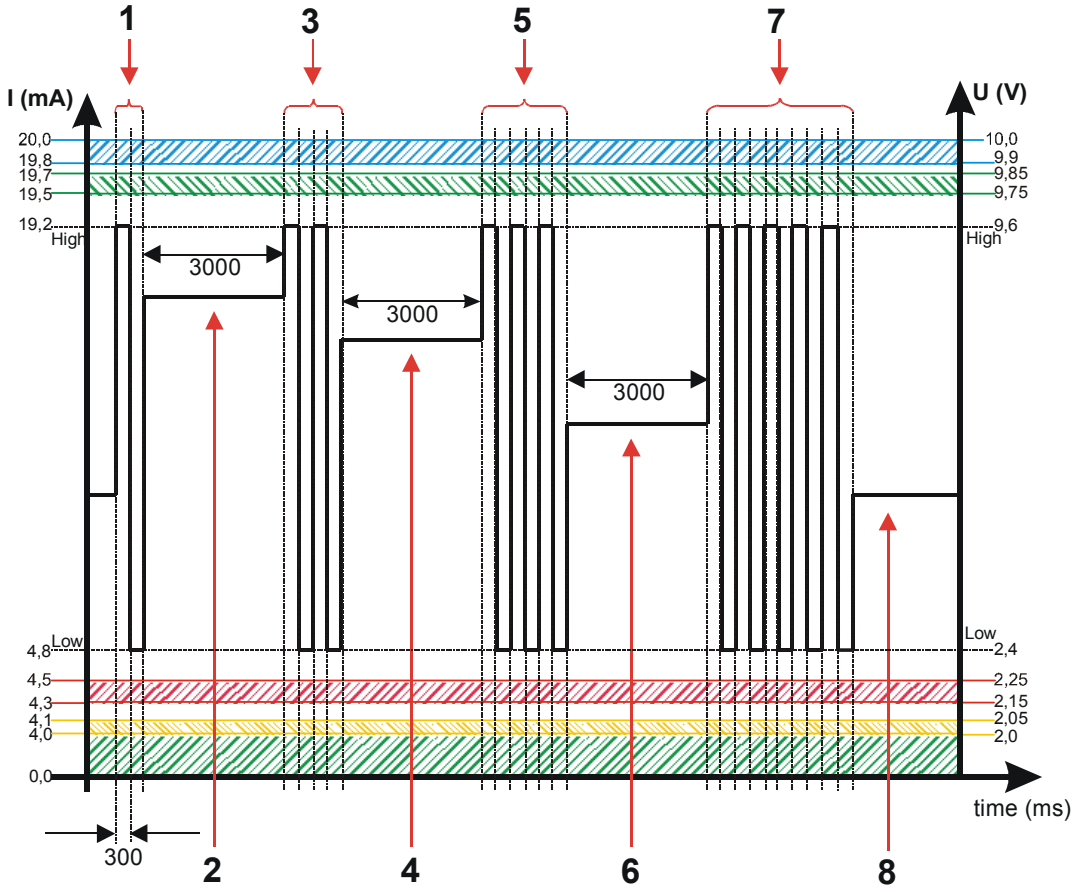
The ISO code signal consists of 3 measured values (>2 µm / >5 µm / >15 µm) which are transmitted time-coded as shown below.



Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	>2µm	300	High / Low
	2	Measured value	>2µm	3000	Current/Voltage for measured value
	3	Identifier	>5µm	300	High / Low / High / Low
	4	Measured value	>5µm	3000	Current/Voltage for measured value
	5	Identifier	>15µm	300	High / Low / High / Low / High / Low
	6	Measured value	>15µm	3000	Current/Voltage for measured value

ISO + T

The ISO+T signal consists of 4 measured values which are transmitted time-coded with the following time slices:

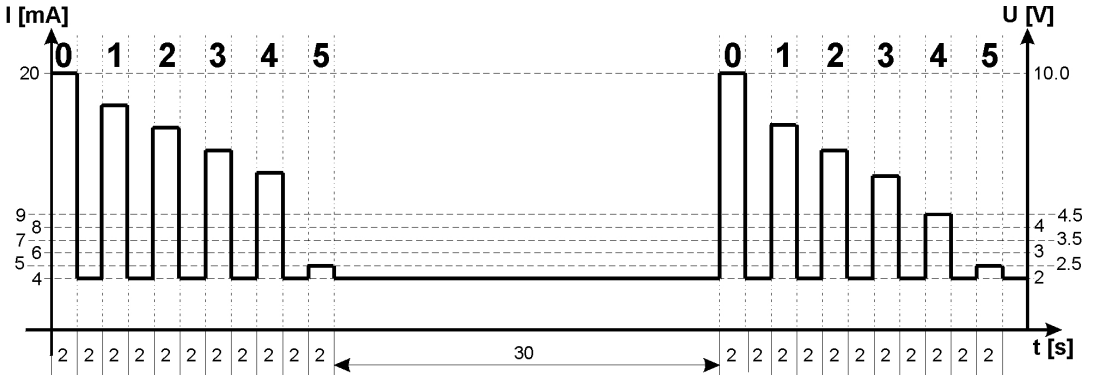


Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	>2µm	300	High / Low
	2	Measured value	>2µm	3000	Current/Voltage for measured value
	3	Identifier	>5µm	300	High / Low / High / Low
	4	Measured value	>5µm	3000	Current/Voltage for measured value
	5	Identifier	>15µm	300	High / Low / High / Low / High / Low
	6	Measured value	>15µm	3000	Current/Voltage for measured value
	7	Identifier	Temperature	300	High / Low / High / Low / High / Low / High / Low / High / Low
	8	Measured value	Temperature	3000	Current/Voltage for measured value

HDA.ISO – Analog signal ISO to HDA 5500

The HDA.ISO signal consists of 4 measured values (ISO 4 / ISO 6 / ISO 14 / ISO 21 / Status) which are output sequentially. Synchronization with the downstream control unit is a prerequisite.

The signal output is as follows:



Time		Measured variable	Signal duration in s	Current/Voltage
	Start signal 0	--	2	20 mA / 10 V
	Pause		2	4 mA / 2 V
	Signal 1	> 4 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 2	> 6 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 3	> 14 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 4	> 21 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 5	Status	2	Current/voltage for signal
	Pause		30	4 mA / 2 V

HDA.ISO Signal 1/2/3/4

The current 4 … 20 mA or voltage 2 … 10 V of the output signal is dependent on the ISO contamination class 0.0 … 24.4 (resolution 1 class) as shown in the table below:

Current I =	ISO Code	Voltage U =
I < 4,00 mA	Cable break	U < 2,00 V
I = 4,00 mA	ISO 0	U = 2,00 V
I = 4,39 mA	ISO 1	U = 2,20 V
I = 5,20 mA	ISO 2	U = 2,60 V
I = 5,92 mA	ISO 3	U = 2,96 V
I = 6,61 mA	ISO 4	U = 3,30 V
I = 7,28 mA	ISO 5	U = 3,64 V
I = 7,95 mA	ISO 6	U = 3,97 V
I = 8,63 mA	ISO 7	U = 4,18 V
I = 9,25 mA	ISO 8	U = 4,62 V
I = 9,91 mA	ISO 9	U = 4,95 V
I = 10,57 mA	ISO 10	U = 5,28 V
I = 11,23 mA	ISO 11	U = 5,61 V
I = 11,89 mA	ISO 12	U = 5,94 V
I = 12,55 mA	ISO 13	U = 6,27 V
I = 13,20 mA	ISO 14	U = 6,60 V
I = 13,86 mA	ISO 15	U = 6,93 V
I = 14,52 mA	ISO 16	U = 7,26 V
I = 15,20 mA	ISO 17	U = 7,60 V
I = 15,82 mA	ISO 18	U = 7,91V
I = 16,48 mA	ISO 19	U = 8,24 V
I = 17,13 mA	ISO 20	U = 8,56 V
I = 17,79 mA	ISO 21	U = 8,90 V
I = 18,45 mA	ISO 22	U = 8,23 V
I = 19,11 mA	ISO 23	U = 9,56 V
I = 19,82 mA	ISO 24	U = 9,90 V
I = 20,00 mA	ISO 24,28	U = 10,0 V

The current (I) or voltage (U) can be calculated for a given ISO contamination class as follows:

I = 4 mA + ISO code x (20 mA - 4 mA) / 24.28

U = 2 V + ISO Code x (10 V - 2 V) / 24.28

The ISO contamination class can be calculated for a given current I or voltage U as follows:

ISO code = (I - 4 mA) x (24.28 / 16 mA)

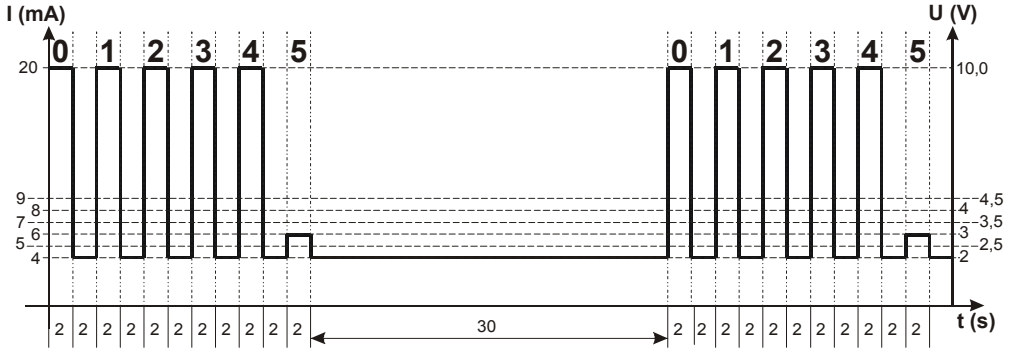
ISO code = (U - 2 V) x (24.28 / 8 V)

HDA.ISO Status Signal 5 (Status)

The current or voltage of the output signal (5) is dependent on the status of the CS1000 as shown in the table below:

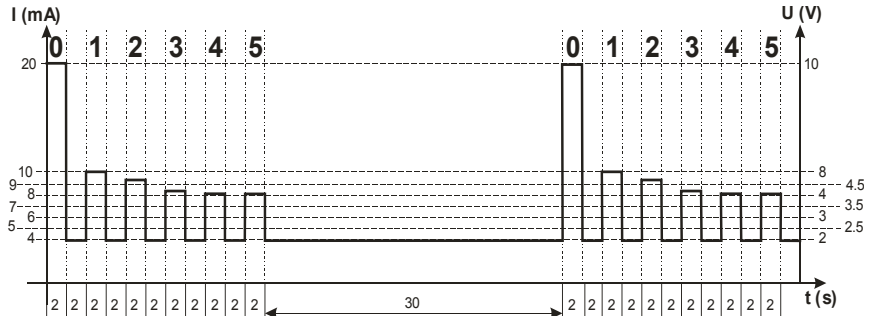
Current I =	Status	Voltage U =
I = 5,0 mA	The CS is functioning correctly.	U = 2,5 V
I = 6,0 mA	Device error / The CS is not ready.	U = 3,0 V
I = 7,0 mA	The flow rate is too low.	U = 3,5 V
I = 8,0 mA	ISO <9.<8.<7	U = 4,0 V
I = 9,0 mA	No measured value (The flow rate is not defined.)	U = 4,5 V

If the status signal is = 6.0 mA or = 3.0 V, signals 1 to 4 are output with 20 mA or 10 V. Example:



If the status signal is 8.0 mA or 4.0 V, signals 1 to 4 are output as follows.

Signal	mA	V
1	10	5.0
2	9.2	4.6
3	8.6	4.3
4	8.0	4.0



NAS 1638 - National Aerospace Standard (Only CS 13xx)

The following NAS values can be read out via the analog output:

- **NAS maximum**

  Only one value is output.

- **NAS (2 / 5 / 15 / 25)**

  All values are sequentially time-coded before output.

- **NAS 2 / NAS 5 / NAS 15 / NAS 25**

  Only one value is output in each case.

- **NAS+T**

  All values are sequentially time-coded before output.

- **HDA.NAS**

  All values are sequentially time-coded before output.
  This signal is planned for the HDA 5500, but it can be used also in other applications.

The current 4.8 … 19.2 mA or voltage 2.4 … 9.6 V of the output signal is dependent on the ISO contamination class 0.0 … 14.0 (resolution 0.1 class) or an error as shown in the table below:

Current I =	NAS Class / Error	Voltage U =
I < 4,00 mA	Cable break	U < 2,00 V
4,0 mA < I < 4,1 mA	Device error, device not ready	2,00 V < U < 2,05 V
4,1 mA < I < 4,3 mA	Not defined	2,05 V < U < 2,15 V
4,3 mA < I < 4,5 mA	Flow error (The flow rate is too low.)	2,15 V < U < 2,25 V
4,5 mA < I < 4,8 mA	Not defined	2,25 V < U < 2,40 V
I = 4,80 mA	NAS 0	U = 2,4 V
I = 4,90 mA	NAS 0,1	U = 2,45 V
I = 5,01 mA	NAS 0,2	U = 2,51 V
…	…	…
I = 5,83 mA	NAS 1	U = 2,92 V
I = 6,86 mA	NAS 2	U = 3,43 V
I = 7,89 mA	NAS 3	U = 3,95 V
I = 8,91 mA	NAS 4	U = 4,46 V
I = 9,94 mA	NAS 5	U = 4,97 V
I = 10,97 mA	NAS 6	U = 5,49 V
I = 12,00 mA	NAS 7	U = 6,00 V
I = 13,03 mA	NAS 8	U = 6,52 V
I = 14,06 mA	NAS 9	U = 7,03 V
I = 15,09 mA	NAS 10	U = 7,55 V
I = 16,11 mA	NAS 11	U = 8,06 V
I = 17,14 mA	NAS 12	U = 8,57 V
I = 18,17 mA	NAS 13	U = 9,09 V
…	…	…

Current I =	NAS Class / Error	Voltage U =
I = 18,99 mA	NAS 13,8	U = 9,50 V
I = 19,10 mA	NAS 13,9	U = 9,55 V
I = 19,20 mA	NAS 14,0	U = 9,60 V
19,2 mA < I < 19,8 mA	Not defined	9,60 V < U < 9,90 V
19,8 mA < I < 20 mA	No measured value	9,90 V < U < 10 V

The current (I) or voltage (U) can be calculated for a given NAS contamination class as follows:

I = 4.8 mA + NAS class x (19.2 mA - 4.8 mA) / 14

U = 2.4 V + NAS class x (9.6 V - 2.4 V) / 14

The current I or voltage U can be calculated for a given NAS contamination class as follows:

NAS class = (I - 4.8 mA) x (14/14.4 mA)

NAS class = (U – 2.4 V) x (14/7.2 V)

NAS maximum

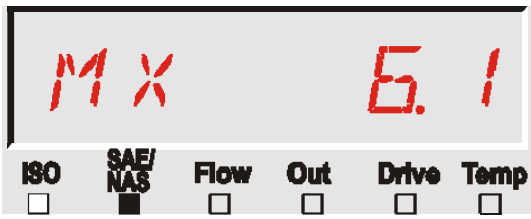
The NASMAX value designates the largest of the 4 NAS classes.

NAS class	2 µm	5 µm	15 µm	25 µm
Particle size	2-5 µm	5-15 µm	15 µm	> 25 µm

The signal is updated after the measuring period has elapsed (the measuring period is set in the PowerUp menu, factory setting = 60 s).

The NASMAX signal is output depending on the maximum NAS class.

Example:

NAS classes	NASMAX (NAS Maximum)
NAS 6.1 / 5.7 / 6.0 / 5.5	

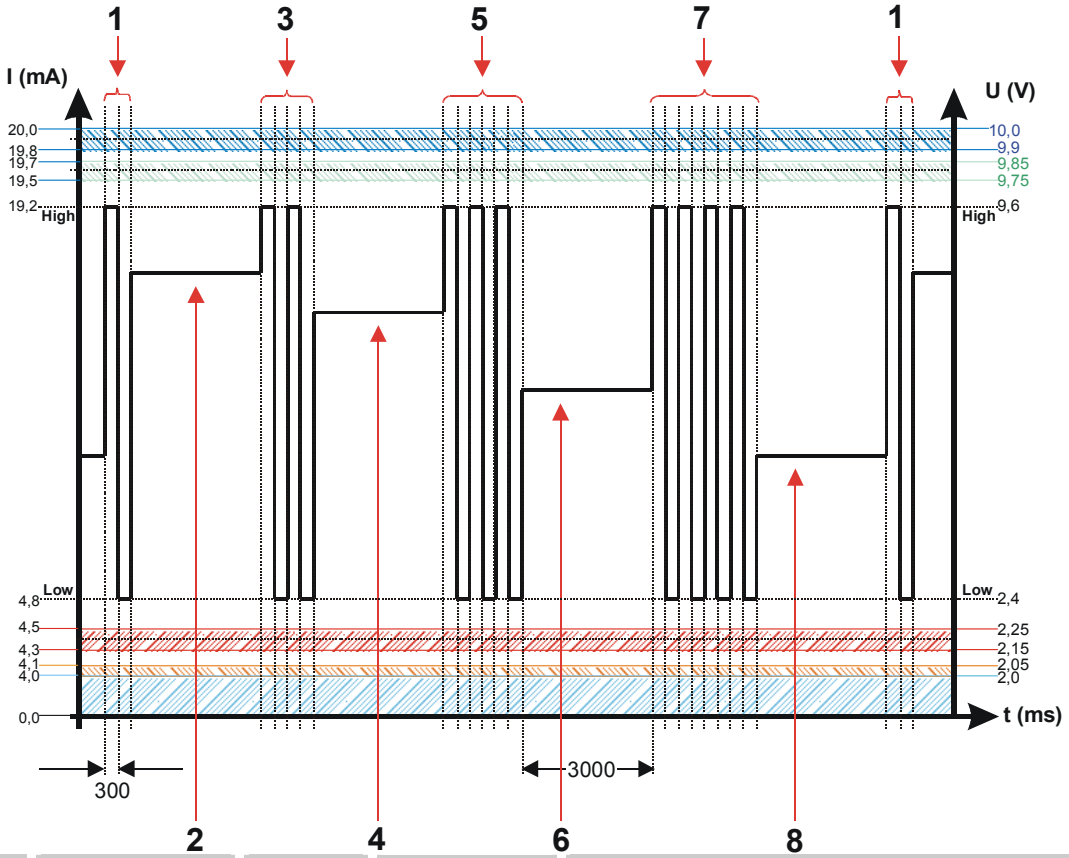
For basic information about cleanliness classes, see Chapter 0.

The NAS classification consists of whole numbers. Better change / trend recognition is based on a resolution of 0.1 contamination classes.

To convert a decimal value to an integer, the decimal value has to be rounded up. For example: a readout of NAS 10.7 is, according to NAS, a class NAS 11.

NAS classes (2 / 5 / 15 / 25)

NAS class signals 2 / 5 / 15 / 25 consist of 4 measured values transmitted with the following time-coded time slices:



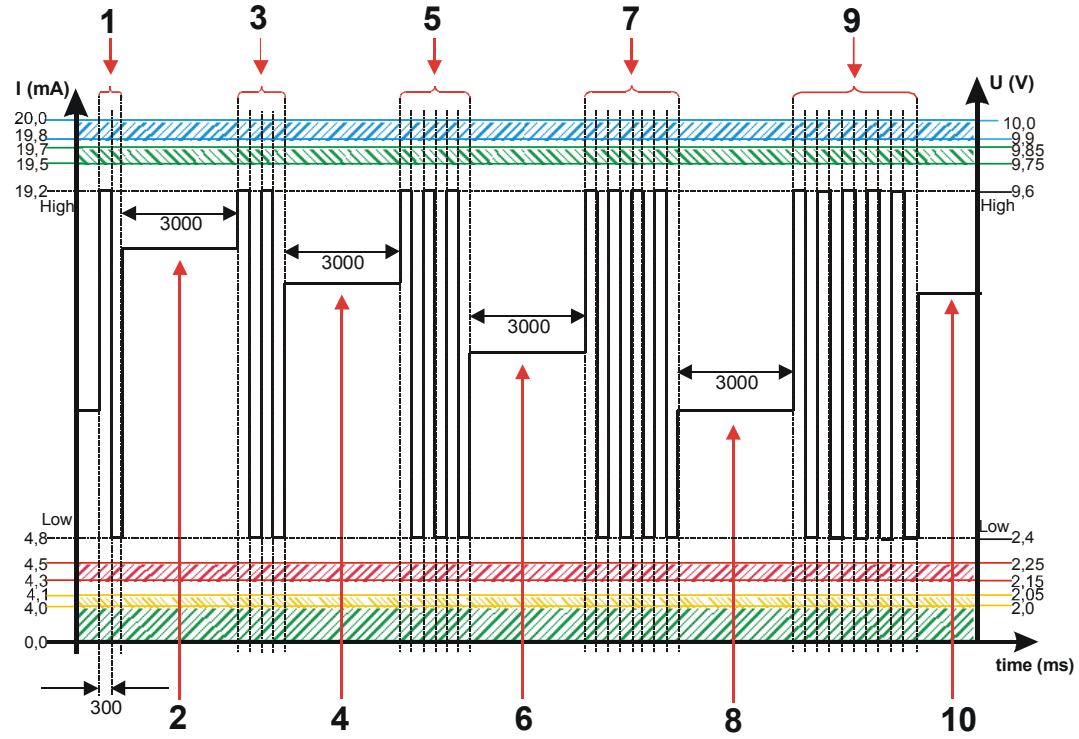
Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	2 µm	300	High / Low
	2	Measured value	2 µm	3000	Current/Voltage for measured value
	3	Identifier	5 µm	300	High / Low / High / Low
	4	Measured value	5 µm	3000	Current/Voltage for measured value
	5	Identifier	15 µm	300	High / Low / High / Low / High / Low
	6	Measured value	15 µm	3000	Current/Voltage for measured value
	7	Identifier	25 µm	300	High / Low / High / Low / High / Low / High / Low
	8	Measured value	25 µm	3000	Current/Voltage for measured value

NAS 2 / NAS 5 / NAS 15 / NAS 25

The NAS x setting enables the value of a class to be continuously output via the analog output.

NAS + T

The NAS+T signal consists of 5 measured values which are transmitted time-coded with the following time slices:

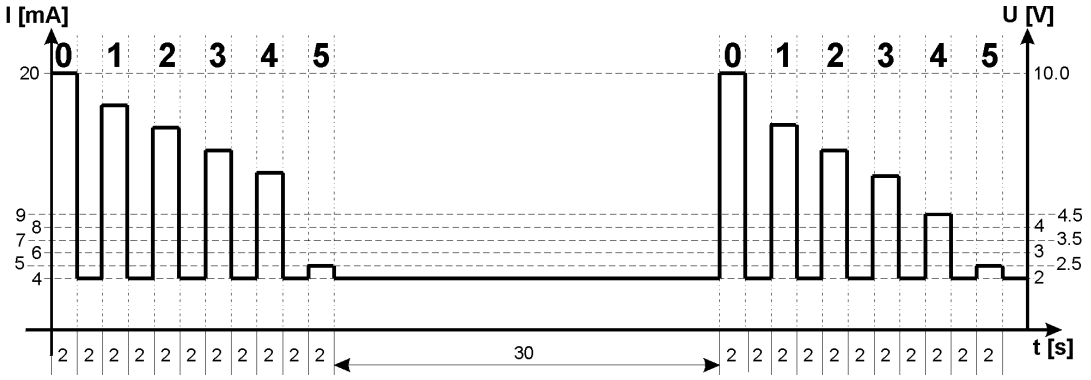


Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	2 µm	300	High / Low
	2	Measured value	2 µm	3000	Current for measured value
	3	Identifier	5 µm	300	High / Low / High / Low
	4	Measured value	5 µm	3000	Current for measured value
	5	Identifier	15 µm	300	High / Low / High / Low / High / Low
	6	Measured value	15 µm	3000	Current for measured value
	7	Identifier	25 µm	300	High / Low / High / Low / High / Low / High / Low
	8	Measured value	25 µm	3000	Current for measured value
	9	Identifier	T	300	High / Low / High / Low / High / Low / High / Low / High / Low
	10	Measured value	T	3000	Current for measured value

HDA.NAS – Analog Signal NAS to HDA 5500

The HDA.NAS signal consists of 4 measured values (Start / NAS 2 / NAS 5 / NAS 15 / NAS 25 / Status) which are output sequentially. Synchronization with the downstream control unit is a prerequisite.

The signal output is as follows:



Time		Measured variable	Signal duration in s	Current/Voltage
	Start signal 0	--	2	20 mA / 10 V
	Pause		2	4 mA / 2 V
	Signal 1	2-5 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 2	5-15 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 3	15-25 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 4	> 25 µm	2	Current / Voltage for signal
	Pause		2	4 mA / 2 V
	Signal 5	Status	2	Current/voltage for signal
	Pause		30	4 mA / 2 V

HDA.NAS Signal 1/2/3/4

The current or voltage range is dependent on the contamination class according to NAS=0.0 … 14.0 (resolution 0.1 class).

Current I =	NAS Class / Error	Voltage U =
I< 4,00 mA	Cable break	U< 2,00 V
I = 4,00 mA	NAS 0	U = 2,00 V
I = 4,11 mA	NAS 0,1	U = 2,06 V
I = 4,23 mA	NAS 0,2	U = 2,11 V
…	…	…
I = 5,14 mA	NAS 1	U = 2,57 V
I = 6,29 mA	NAS 2	U = 3,14 V
I = 7,43 mA	NAS 3	U = 3,71 V
I = 8,57 mA	NAS 4	U = 4,29 V
I = 9,71 mA	NAS 5	U = 4,86 V
I = 10,86 mA	NAS 6	U = 5,43 V
I = 12,00 mA	NAS 7	U = 6,00 V
I = 13,14 mA	NAS 8	U = 6,57 V
I = 14,29 mA	NAS 9	U = 7,14 V
I = 15,43 mA	NAS 10	U = 7,71 V
I = 16,57 mA	NAS 11	U = 8,29 V
I = 17,71 mA	NAS 12	U = 8,86 V
I = 18,86 mA	NAS 13	U = 9,43 V
…	…	…
I = 19,77 mA	NAS 13,8	U = 9,89 V
I = 19,89 mA	NAS 13,9	U = 9,94 V
I = 20,00 mA	NAS 14,0	U = 10,00 V

The current (I) or voltage (U) can be calculated for a given NAS contamination class as follows:

I = 4 mA + NAS class x (20 mA - 4 mA) / 14

U = 2 V + NAS class x (10 V - 2 V) / 14

The current I or voltage U can be calculated for a given NAS contamination class as follows:

NAS class = (I - 4 mA) x (14/16 mA)

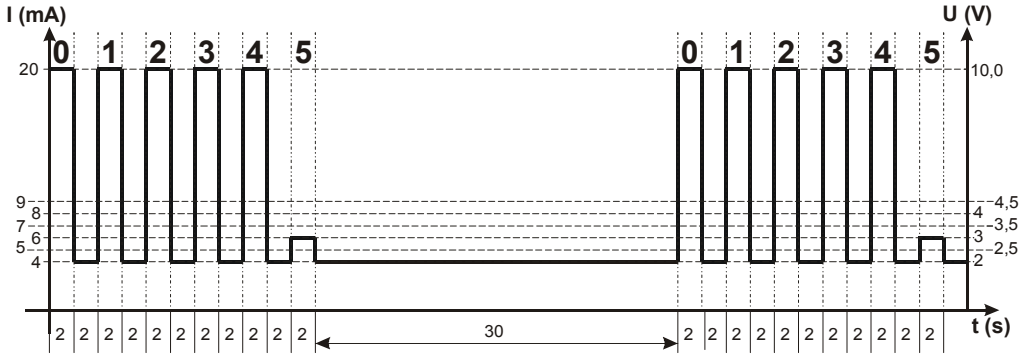
NAS class = (U – 2 V) x (14/8 V)

HDA.NAS Status Signal 5 (Status)

The current or voltage of the output signal (5) is dependent on the status of the CS1000 as shown in the table below:

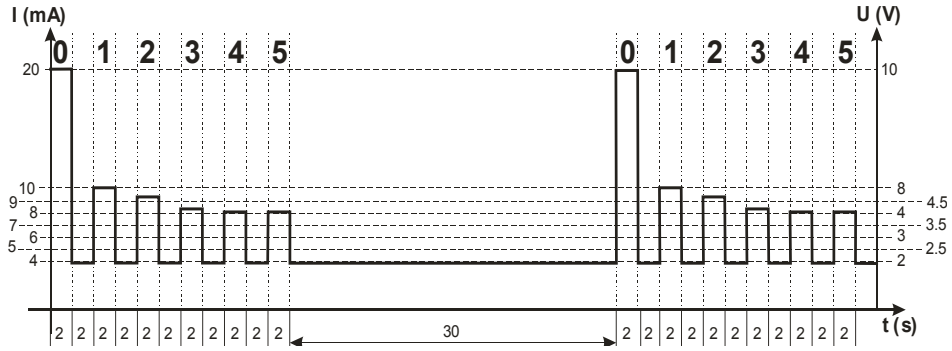
Current I =	Status	Voltage U =
I = 5,0 mA	The CS is functioning correctly.	U = 2,5 V
I = 6,0 mA	Device error / The CS is not ready.	U = 3,0 V
I = 7,0 mA	The flow rate is too low.	U = 3,5 V
I = 8,0 mA	NAS < 0	U = 4,0 V
I = 9,0 mA	No measured value (The flow rate is not defined.)	U = 4,5 V

If the status signal is 6.0 / 7.0 / 9.0 mA or 3.0 / 3.5 / 4.5 V, signals 1 to 4 are output with 20 mA or 10 V. Example:



If the status signal is 8.0 mA or 4.0 V, signals 1 to 4 are output as follows.

Signal	mA	V
1	10	5.0
2	9.2	4.6
3	8.6	4.3
4	8.0	4.0



Fluid temperature TEMP

The current range 4.8 … 19.2 mA or voltage range 2.4 … 9.6 V is dependent on the fluid temperature of -25°C … 100°C (resolution: 1°C) or -13°F … 212°F (resolution: 1°F) as shown in the table below.

Current I =	Temperature / Error	Voltage U =
I < 4,00 mA	Cable break	U < 2,00 V
4,0 mA < I < 4,1 mA	Device error, device not ready	2,00 V < U < 2,05 V
4,1 mA < I < 4,3 mA	Not defined	2,05 V < U < 2,15 V
4,3 mA < I < 4,5 mA	Flow error (The flow rate is too low.)	2,15 V < U < 2,25 V
4,5 mA < I < 4,8 mA	Not defined	2,25 V < U < 2,40 V
I = 4,8 mA	-25 °C / -13 °F	U = 2,40 V
…	…	…
I = 7,68 mA	0 °C / 32 °F	U = 3,84 V
I = 8,26 mA	+5 °C / 41 °F	U = 4,13 V
I = 8,83 mA	+10 °C / 50 °F	U = 4,42 V
I = 9,41 mA	+15 °C / 59 °F	U = 4,70 V
I = 9,98 mA	+20 °C / 68 °F	U = 4,99 V
I = 10,56 mA	+25 °C / 77 °F	U = 5,28 V
I = 11,14 mA	+30 °C / 86 °F	U = 5,57 V
I = 11,71 mA	+35 °C / 95 °F	U = 5,86 V
I = 12,29 mA	+40 °C / 104 °F	U = 6,14 V
I = 12,86 mA	+45 °C / 113 °F	U = 6,43 V
I = 13,44 mA	+50 °C / 122 °F	U = 6,72 V
I = 14,02 mA	+55 °C / 131 °F	U = 7,01 V
I = 14,59 mA	+60 °C / 140 °F	U = 7,30 V
I = 15,17 mA	+65 °C / 149 °F	U = 7,58 V
I = 15,74 mA	+70 °C / 158 °F	U = 7,87 V
I = 16,32 mA	+75 °C / 167 °F	U = 8,16 V
I = 16,90 mA	+80 °C / 176 °F	U = 8,45 V
I = 17,47 mA	+85 °C / 185 °F	U = 8,74 V
I = 18,05 mA	+90 °C / 194 °F	U = 9,02 V
I = 18,62 mA	+95 °C / 203 °F	U = 9,31 V
I = 19,20 mA	+100 °C / 212 °F	U = 9,60 V
19,2 mA < I < 19,8mA	Not defined	9,60 V < U < 9,90 V
19,8 mA < I < 20 mA	No measured value	9,90 V < U < 10 V

The current I or voltage U can be calculated for a given temperature as follows:

I = 4.8 mA + (temperature [°C] + 25) x (19.2 mA - 4.8 mA) / 125

I = 4.8 mA + (temperature [°F] +13) x (19.2 mA - 4.8 mA) / 225

U = 2.4 V + (temperature [°C] + 25) x (9.6 V - 2.4 V) / 125

U = 2.4 V + (temperature [°F] + 13) x (9.6 V-2.4 V) / 225

The temperature in °C or °F can be calculated for a given current I or voltage U as follows:

Temperature [°C]= ((I - 4.8 mA) x (125 / 14.4 mA)) - 25

Temperature [°F]= ((I - 4.8 mA) x (225 / 14.4 mA)) - 13

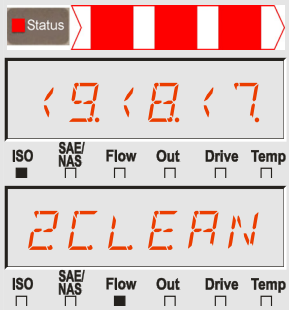
Temperature [°F]= ((U - 2.4 V) x (125 / 7.2 V)) - 25

Temperature [°F]= ((U - 2.4 V) x (225 / 7.2 V)) - 13

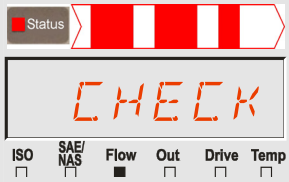
Status Messages

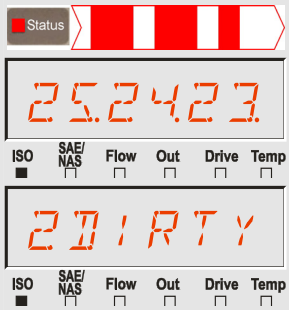
Status LED / Display

LED	Blink code / Display / Analog output / Switch out	Status	To do	Error no.
Green	Conductive	CS o.k.	---	-
Green	19,9 mA / 9,95 V* Open	The flow rate has reached the upper limit.	Reduce the flow rate to prevent the sensor from going into the CHECK error state.	-
Green	19,9 mA / 9,95 V* Open	The flow rate has reached the upper permissible range.	Check the flow rate in short cycles. The sensor is in the upper permissible flow rate range.	-
Green	19,9 mA / 9,95 V* Open	The flow rate is in the middle permissible range.	Do nothing. The sensor is in the middle flow rate range.	-
Green	19,9 mA / 9,95 V* Open	The flow rate has reached the lower permissible range.	Check the flow rate in short cycles. The sensor is in the lower permissible flow rate range.	-
Green	19,9 mA / 9,95 V* Open	The flow rate has reached the lower limit.	Increase the flow rate to prevent the sensor from going into the CHECK error state.	-

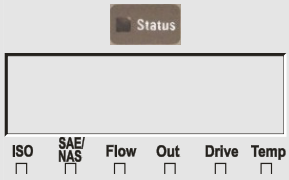
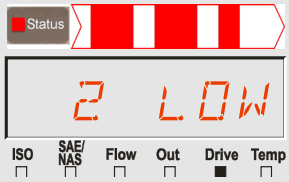
LED	Blink code / Display / Analog output / Switch out	Status	To do	Error no.
Red	 Current value mA / V* Conductive	The sensor is below its measurement range ISO 9/8/7	---	-

error

LED	Blink code / Display / Analog output / Switch out	Status	To do	Error no.
Red	 19,9 mA / 9,95 V* Open	It is not possible to determine the flow rate. The sensor status is undefined.	Check that the flow is between 30 … 500 ml/min. If the fluid cleanliness is below the measurement limit (ISO 9/8/7), it may take several measurement cycles until measured values are displayed.	3

LED	Blink code / Display / Analog output / Switch out	Status	To do	Error no.
Red	 19.9 mA / 9.95 V* Open	The sensor is above its measurement range ISO 25/24/23. It is not possible to determine the flow rate.	Filter the fluid.	3

Exceptions Errors

LED	Blink code / Display / Analog output / Switch output	CS1000 Status	To do	Error no.
OFF	 0 mA / 0 V* Open	CS no display no function.	Check the supply voltage for the CS. Contact HYDAC.	-
Red	 4.1 mA / 2.05 V* or 19.9 mA / 9.95 V Open	"2 low" on "Drive"	If the CS is supplied with 24 V, then reduce the supply voltage to 12 V. If the error persists, contact HYDAC.	-

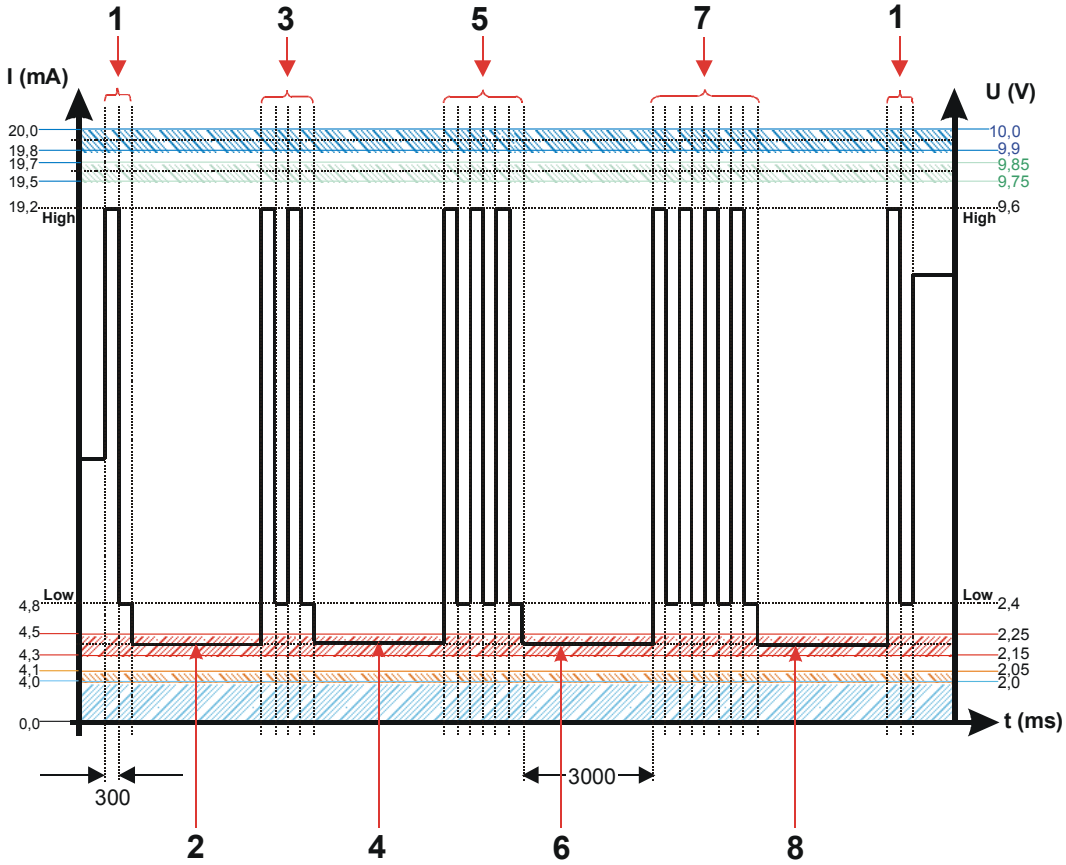
LED	Blink code / Display / Analog output / Switch output	CS1000 Status	To do	Error no.
Red	4,1 mA / 2,05 V* Open	Firmware error	Perform a reset. (To do this, disconnect the CS from the voltage supply) or contact HYDAC.	-1…-19
Red	4,1 mA / 2,05 V* Open	Communic. error	Check the wiring.	-20…-39
Red	4,1 mA / 2,05 V* Open	System error	Perform a reset. (To do this, disconnect the CS from the voltage supply) or contact HYDAC.	-40…-69
Red	4,1 mA / 2,05 V* Open	Error during automatic adjustment	Perform a reset. (To do this, disconnect the CS from the voltage supply) / check the flow rate or contact HYDAC.	-70
Red	4,1 mA / 2,05 V* Open	Error measuring cell LED	Perform a reset. (To do this, disconnect the CS from the voltage supply) / check the flow rate or contact HYDAC.	-100

* Is not valid for HDA 5500 output signal

Analog Output Error Signals

If the CS enters into an error status all following measured value signals are output in a specific current strength (I) or voltage (U). Please refer to chapter "Error status" for the respective values for the current strength or voltage of the output signal during an error status). The time coding is preserved.

Example: "CHECK" error for the SAE output signal.



Time		Signal	Size	Signal duration per pulse in ms	Current (I) / Voltage (U)
	1	Identifier	SAE A	300	High / Low
	2	Measured value	SAE A	3000	4,4 mA / 2,2 V
	3	Identifier	SAE B	300	High / Low / High / Low
	4	Measured value	SAE B	3000	4,4 mA / 2,2 V
	5	Identifier	SAE C	300	High / Low / High / Low / High / Low
	6	Measured value	SAE C	3000	4,4 mA / 2,2 V
	7	Identifier	SAE D	300	High / Low / High / Low / High / Low / High / Low
	8	Measured value	SAE D	3000	4,4 mA / 2,2 V

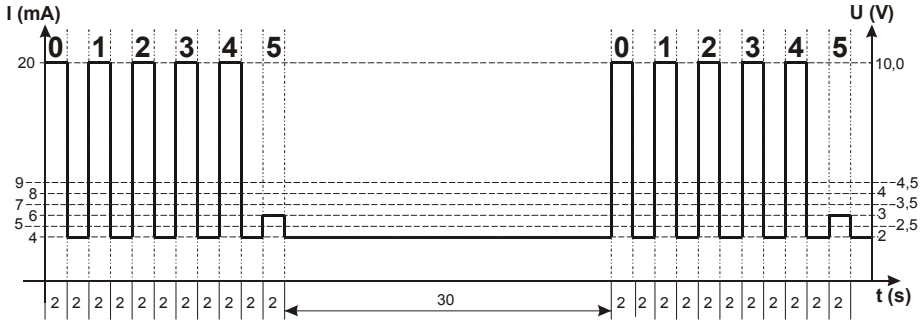
Analog signal for HDA 5500

HDA Status Signal 5 Table

The current or voltage of the analog signal (5) is dependent on the status of the CS1000 as shown in the table below:

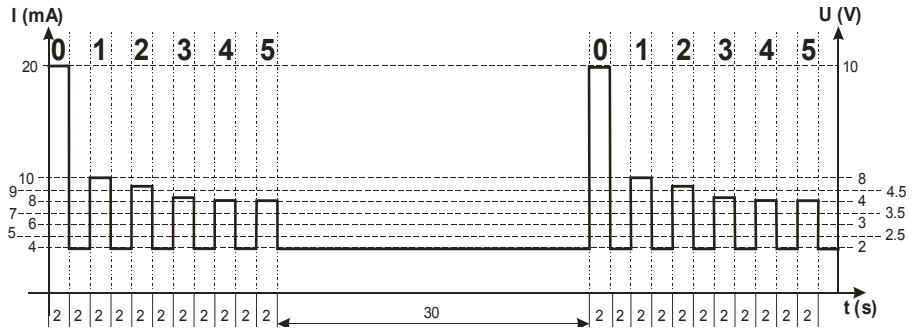
Current I =	Status	Voltage U =
I = 5,0 mA	The CS is functioning correctly.	U = 2,5 V
I = 6,0 mA	Device error / The CS is not ready.	U = 3,0 V
I = 7,0 mA	The flow rate is too low.	U = 3,5 V
I = 8,0 mA	ISO <9.<8.<7	U = 4,0 V
I = 9,0 mA	No measured value (The flow rate is not defined.)	U = 4.5V

If the status signal is 6.0 / 7.0 / 9.0 mA or 3.0 / 3.5 / 4.5 V, signals 1 to 4 are output with 20 mA or 10 V. Example:



If the status signal is 8.0 mA or 4.0 V, signals 1 to 4 are output as follows.

Signal	mA	V
1	10	5.0
2	9.2	4.6
3	8.6	4.3
4	8.0	4.0



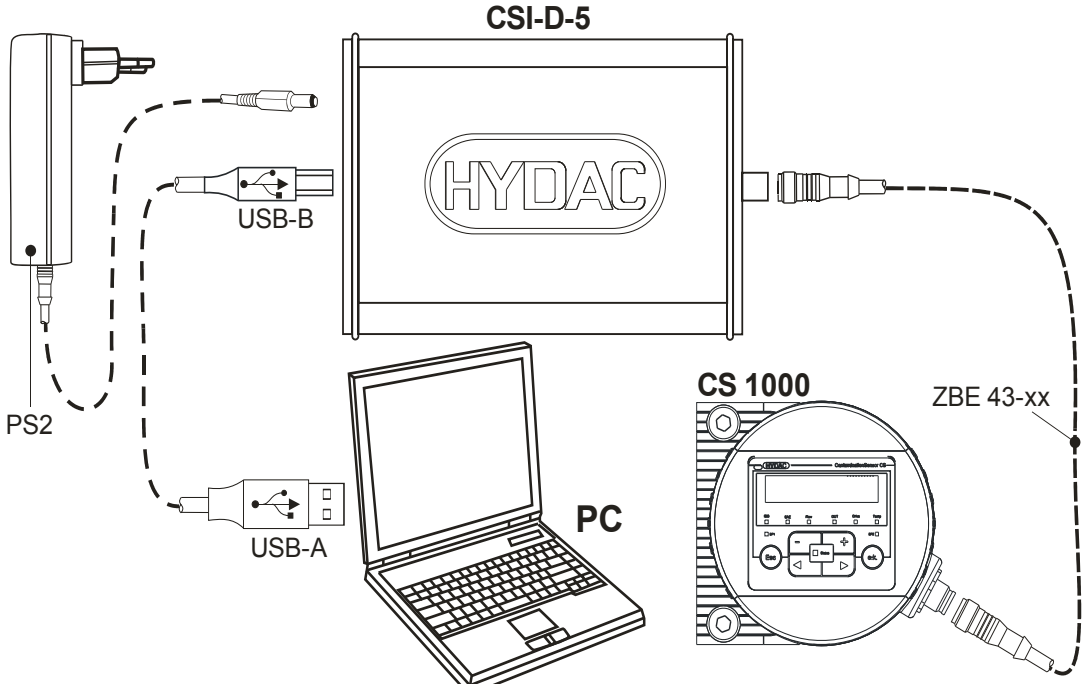
Connecting CSI-D-5 (Condition Sensor Interface)

The CSI-D-5 makes it possible to operate the CS1000 using a PC:

- Setting parameters and limit values.
- Reading out measurement data online.

CSI-D-5 Connection overview

Connect the CSI-D-5 to the CS according to the following connection diagram:



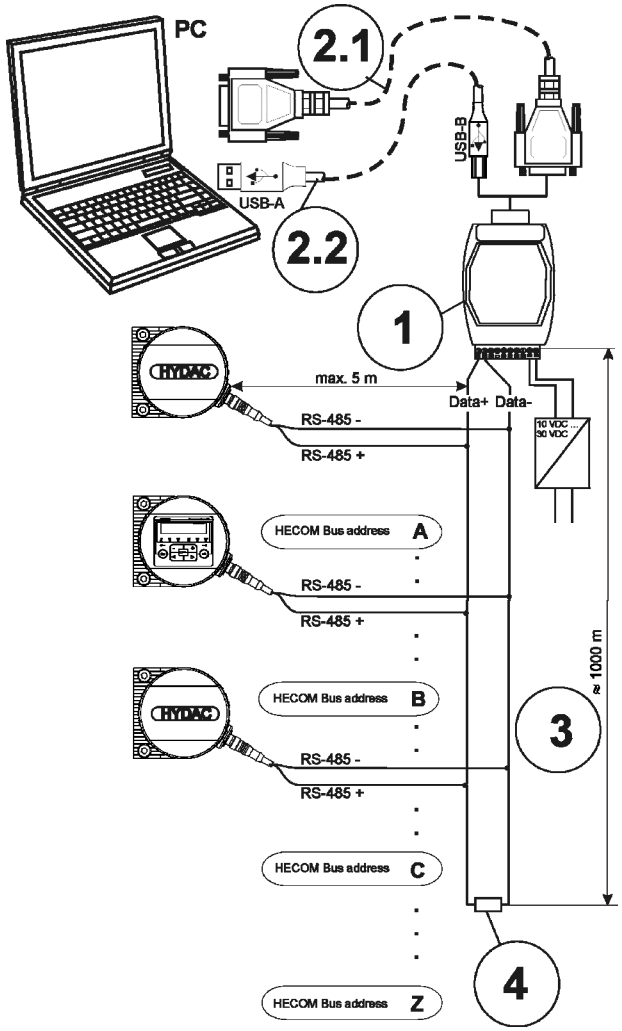
Connecting the CS1000 to an RS-485 bus

The RS-485 interface on the CS1000 is a two-wire interface and operates in half-duplex mode.

The number of CS1000s per RS-485 bus is limited to 26. Use letters A to Z to address the HECOM bus address.

The length of the bus line and the size of the terminating resistor depend on the quality of cable used.

Connect several CS1000's using the RS-485 interfaces according to the following illustration:



Item	Code		Part no.:
1	Converter	RS232 <-> RS485	6013281
1	Converter	USB <-> RS485	6042337
2.1	Connection cable	RS232, 9-pole	-
2.2	Connection cable	USB [A] <-> USB [B]	-
3	Recommended cable	twisted pair	-
4	Terminator	~ 120 Ω	-

Communicating with the CS1000 via the RS-485 bus

To communicate with the CS1000, start a terminal program (e,g, Hyperterminal) on the PC.

Use the following settings to communicate via the COM interface:

Transfer rate (bps):	9600 Baud
Data bits:	8
Parity:	None
Stop bits:	1
Log:	None

The CS1000 can send and receive only HSI commands.

An overview of the HSI commands is provided in our "Getting started" guide for HSI commands, p/no.: 3737763. This "Getting started" guide is available as a PDF on request by e-mailing fltersystems@hydac.com.

Taking the CS1000 out of operation

To decommission, proceed as follows:

1. Disconnect and remove the electric connection to the CS.
2. Close any shut-off devices in the feed and return lines of the CS.
2. Depressurize the unit.
3. Remove the hydraulic connection lines to the CS.
4. Remove the CS.

Disposing of CS1000

Dispose of the packaging material in an environmentally-friendly manner.

After dismantling the unit and separating the various materials, dispose of the unit in an environmentally friendly manner.

Spare Parts and Accessories

Code		Qty	Part no.
CD-ROM with operating and maintenance instructions in different languages		1	3764919
ContaminationSensor Interface	CSI-D-5	1	3249563
O-ring for the flange connection	(4.8x1.78 - 80 Shore FKM)	1	6003048
Socket plug (female) with 2 m line, shielded, 8-pole, M12x1	ZBE 42-02	1	3281220
Socket plug (female) with 5 m line, shielded, 8-pole, M12x1	ZBE 42-05	1	3281239
Extension cable 5 m, Socket plug (female) 8-pole, M12x1 / Socket plug (male) 8-pole, M12x1	ZBE 43-05	1	3281240
Socket plug (female), 8-pole, M12x1, with screw clamp	ZBE 44	1	3281243
Hydac Digital display unit	HDA5500-0-2-AC-006	1	909925
Hydac Digital display unit	HDA5500-0-2-DC-006	1	909926

Cleanliness classes - brief overview

Cleanliness class - ISO 4406:1999

In ISO 4406:1999, particle counts are determined cumulatively, i.e. > 4 $\mu m_{(c)}$, >6 $\mu m_{(c)}$ and >14 $\mu m_{(c)}$ (manually by filtering the fluid through an analysis membrane or automatically using particle counters) and allocated to measurement references.

The goal of allocating particle counts to references is to facilitate the assessment of fluid cleanliness ratings.

In 1999 the "old" ISO 4406:1987 was revised and the size ranges of the particle sizes undergoing analysis redefined. The counting method and calibration were also changed.

This is important for the user in his everyday work: even though the measurement references of the particles undergoing analysis have changed, the cleanliness code will change only in individual cases. When drafting the "new" ISO 4406:1999 it was ensured that not all the existing cleanliness provisions for systems had to be changed.

Table - ISO 4406

Assignment of particle counts to cleanliness classes:

	Particle count / 100 ml			Particle count / 100 ml	
Class	**More than**	**Up to (and including)**	**Class**	**More than**	**Up to (and including)**
0	0	1	**15**	16,000	32,000
1	1	2	**16**	32,000	64,000
2	2	4	**17**	64,000	130,000
3	4	8	**18**	130,000	250,000
4	8	16	**19**	250,000	500,000
5	16	32	**20**	500,000	1,000,000
6	32	64	**21**	1,000,000	2,000,000
7	64	130	**22**	2,000,000	4,000,000
8	130	250	**23**	4,000,000	8,000,000
9	250	500	**24**	8,000,000	16,000,000
10	500	1,000	**25**	16,000,000	32,000,000
11	1,000	2,000	**26**	32,000,000	64,000,000
12	2,000	4,000	**27**	64,000,000	130,000,000
13	4,000	8,000	**28**	130,000,000	250,000,000
14	8,000	16,000			

Note: increasing the measurement reference by 1 causes the particle count to double.

Example: ISO class 18 / 15 / 11 means:

Cleanliness class	Particle count / ml	Size ranges
18	1,300 – 2,500	> 4 $\mu m_{(c)}$
15	160 – 320	> 6 $\mu m_{(c)}$
11	10 – 20	> 14 $\mu m_{(c)}$

Overview of modifications - ISO4406:1987 <-> ISO4406:1999

	"old" ISO 4406:1987	"new" ISO 4406:1999	
Size ranges	 > 5 µm > 15 µm		> 4 $\mu m_{(c)}$ > 6 $\mu m_{(c)}$ > 14 $\mu m_{(c)}$
Dimension determined	Longest dimension of a particle		Diameter of the area-equivalent circle ISO 11171:1999
Test dust	ACFTD dust	1-10 µm ultra fine fraction	ISO 12103-1A1
		SAE Fine, AC Fine	ISO 12103-1A2
		SAE 5-80 µm ISO MTD Calibration dust for particle counters	ISO 12103-1A3
		SAE Coarse Coarse fraction	ISO 12103-1A4
Comparable size ranges	Old ACFTD calibration	Comparable ACFTD dusts	New NIST calibration
	----- 5 µm 15 µm	< 1 µm 4,3 µm 15,5 µm	4 $\mu m_{(c)}$ 6 $\mu m_{(c)}$ 14 $\mu m_{(c)}$

Cleanliness class - SAE AS 4059

Like ISO 4406, NAS 4059 describes particle concentrations in liquids. The analysis methods can be applied in the same manner as ISO 4406:1999.

An additional feature in common with ISO 4406:1999 is that cleanliness classes are grouped on the basis of cumulative number of particles (i.e. all particles that are larger than a certain limit value are >4 µm, for example).

As opposed to ISO, SAE AS 4059 uses different limit values among the various particle sizes for contamination classes.

For this reason, the corresponding designation of the particle size being examined always has to be added, e.g.:

AS 4059 class 6B -> 9731 – 19500 particles >6 µm

AS 4059 class 8A/7B/6C -> 3-value ISO code >4µm/>6µm/>14µm

If an SAE class is given acc. to AS 4059 without a letter, then it is always particle size B (> 6 µm).

The following table shows the cleanliness classes in relation to the particle concentration determined:

Table - SAE AS 4059

		Maximum particle count / 100 ml					
Size ISO 4402		**> 1 µm**	**> 5 µm**	**> 15 µm**	**> 25 µm**	**> 50 µm**	**> 100 µm**
Size ISO 11171		**> 4 µm(c)**	**> 6 µm(c)**	**> 14 µm(c)**	**> 21 µm(c)**	**> 38 µm(c)**	**> 70 µm(c)**
Size coding		**A**	**B**	**C**	**D**	**E**	**F**
Classes	000	195	76	14	3	1	0
	00	390	152	27	5	1	0
	0	780	304	54	10	2	0
	1	1,560	609	109	20	4	1
	2	3,120	1,220	217	39	7	1
	3	6,250	2,430	432	76	13	2
	4	12,500	4,860	864	152	26	4
	5	25,000	9,730	1,730	306	53	8
	6	**50,000**	**19,500**	**3,460**	**612**	**106**	**16**
	7	100,000	38,900	6,920	1,220	212	32
	8	200,000	77,900	13,900	2,450	424	64
	9	400,000	156,000	27,700	4,900	848	128
	10	800,000	311,000	55,400	9,800	1,700	256
	11	1,600,000	623,000	111,000	19,600	3,390	512
	12	3,200,000	1,250,000	222,000	39,200	6,780	1,020

Definition acc. to SAE

Particle count (absolute) larger than a defined particle size

Example: Cleanliness class according to AS 4059: 6

The maximum permissible particle count in the individual size ranges is bold-faced in the table on page 98.

Cleanliness class acc. to AS 4059= 6 B

Size B particles may not exceed the maximum number indicated for code 6: 6 B = max. 19,500 particles > 5 µm in size

Specifying a cleanliness code for each particle size

Example: Cleanliness class according to AS 4059=7 B / 6 C / 5 D

Cleanliness class	Max. particles / 100 ml
Size B (> 5 µm / > 6 $\mu m_{(c)}$)	38,900
Size C (>15 µm / >14 $\mu m_{(c)}$)	3460
Size D (>25 µm / > 21 $\mu m_{(c)}$)	306

Specifying highest measured cleanliness class

Example: Cleanliness class according to AS 4059= 6 B – F

The 6 B – F specification requires a particle count in size ranges B – F. The respective particle concentration of cleanliness class 6 may not be exceeded in any of these ranges.

Cleanliness Class - NAS 1638

Like ISO 4406, NAS 1638 describes particle concentrations in liquids. The analysis methods can be applied in the same manner as ISO 4406:1987.

In contrast to ISO 4406, certain particle ranges are counted in NAS 1638 and attributed to measurement references.

The following table shows the cleanliness classes in relation to the particle concentration determined:

		Maximum particle count / 100 ml					
		2..5 µm	5..15 µm	15..25 µm	25..50 µm	50..100 µm	> 100 µm
Cleanliness class	00	625	125	22	4	1	0
	0	1,250	250	44	8	2	0
	1	2,500	500	88	16	3	1
	2	5,000	1,000	178	32	6	1
	3	10,000	2,000	356	64	11	2
	4	20,000	4,000	712	128	22	4
	5	40,000	8,000	1,425	253	45	8
	6	80,000	16,000	2,850	506	90	16
	7	160,000	32,000	5,700	1,012	180	32
	8	320,000	64,000	11,400	2,025	360	64
	9	640,000	128,000	22,800	4,050	720	128
	10	1,280,000	256,000	45,600	8,100	1,440	256
	11	2,560,000	512,000	91,200	16,200	2,880	512
	12	5,120,000	1,024,000	182,400	32,400	5,760	1,024
	13	10,240,000	2,048,000	364,800	64,800	11,520	2,048
	14	20,480,000	4,096,000	729,000	129,600	23,040	4,096

Increasing the class by 1 causes the particle count to double on average.

Checking/resetting default settings

PowerUp menu

PowerUp menu	Value	
MODE	M1	
M.TIME	60	
P.PRTCT	0	
ADRESS	HECOM	A
CALID	ISO.NAS	(CS 13xx, only)

Mode	Value				
MODE	M2	SP1	MEAS.CH	SAE.MAX	
MODE	M2	SP1	SW.FNCT	BEYOND	
MODE	M2	SP1	LIMITS	LOWER	17.15.12
MODE	M2	SP1	LIMITS	UPPER	21.19.16
MODE	M3	MEAS.CH	ISO		
MODE	M3	TARGET	17.15.12		
MODE	M4	MEAS.CH	ISO		
MODE	M4	TARGET	17.15.12		
MODE	M4	RESTART	21.19.16		
MODE	M4	CYCLE	60		

Measuring menu

Measuring Menu	Value
DSPLY	ISO
SWT.OUT	M1
ANAOUT	HDR.ISO

Technical data

General data		
Mounting position	Any (recommended: vertical position)	
Self-diagnosis	continuously with error indication via status LED and display	
Display (only CS 1x2x)	LED, 6 digits, in 17 segment format	
Measured variables	CS 12xx	ISO / SAE
	CS 13xx	ISO / SAE / NAS
Service variables	Flow	ml/min
	Out	mA or VDC depending on model
	Drive	%
	Temp	°C and °F
Ambient temperature range	-30 … 80 °C / -22 … 176 °F	
Storage temperature range	-40 … 80 °C / -40 … 176 °F	
Relative humidity	max. 95%, non-condensing	
Material of seals	CS 1xx0	FKM
	CS 1xx1	EPDM
Protection class	III (safety extra-low voltage)	
IP class	IP 67	
Weight	~ 1,3 kg	
Hydraulic data		
Operating pressure	maximum 350 bar / 5075 psi	
Hydraulic connection		
- Pipe/hose connection	Thread G ¼ according to ISO 228	
- Flange connection	DN 4	
Permitted measurement flow rate	30 … 500 ml/min	
Permissible viscosity range	1 … 1000 mm²/s	
Fluid temperature range	0 …80 °C / 32 …185 °F	
Electrical data		
Connection plug	M12x1, 8 pole, specified in DIN VDE 0627	
Supply voltage	9 … 36 V DC, residual ripple < 10%, (protected against polarity reversal)	
Power consumption	3 W max.	
Analogue output	2-conductor technology 4 … 20 mA active output (max. burden 330Ω) or 2 … 10 V active output (minimum load resistance 820 Ω)	
Switching output	passive, n-switching Power MOSFET: maximum switching current 2 A, maximum switching voltage 30 V DC, dead open	

RS485 Interface	2 wire, half duplex
HSI (**H**YDAC **S**ensor **I**nterface)	1 wire, half duplex

Recalibration

We recommend recalibrating the sensor every 2 … 3 years unless regulated differently by quality assurance.

Customer Service

For calibration and repair, send the sensor to the following address:

Germany

HYDAC Service GmbH
Product Support, Werk 13
Friedrichsthaler Straße 15A
66540 Neunkirchen-Heinitz

Telephone:	++49 (0) 6897 509 883
Telefax:	++49 (0) 6897 509 324
E-Mail:	service@hydac.com

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E-Mail: hydac@hydac.com.br

Homepage www.hydac.com.br

China

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28 Zhongpin Lu
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Technological Development Zone
SHANGHAI 200245; P.R. CHINA

Telephone: (0086) 21/64 63 35 10

Telefax: (0086) 21/64 30 02 57

E-Mail: hydacsh@hydac.com.cn

Model Code

	CS	1	0	0	0	-	A	-	0	-	0	-	0	-	0	/-	000

Product

CS = ContamionationSensor

Series

1 = 1000 series

Contamination code

2 = ISO4406:1999; SAE AS4059 (D)

3 = ISO4406:1987; NAS 1638
ISO4406:1999; SAE AS4059 (D)

Options

1 = without display

2 = with display, continuously variable rotation by 270°

Fluids

0 = petroleum-based

1 = for phosphate esters

Analog interfaces

A = 4 … 20 mA

B = 2 … 10 V

Switching output

0 = Switch output threshold

Digital interface

0 = RS485

Electrical connection

0 = plug connection M12x1, 8-pin, pin, according to VDE0627 or IEC61984

Hydraulic connection type

0 = Pipe or hose connection

1 = Flange connection

Modification Number

000 = Standard

EC declaration of conformity

FILTER SYSTEMS

HYDAC FILTER SYSTEMS GMBH
Postfach 12 51
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Germany

Industriegebiet
66280 Sulzbach / Saar
Germany

Telefon: ++49 (0) 6897 509 01
Internet: www.hydac.com

EC declaration of conformity

We hereby declare that the following designated product, on the basis of its design and construction, and in the version which we have brought to market, corresponds to the fundamental safety and health requirements contained in the standards listed below.

Any modification of this product that is not coordinated with us in writing will cause this declaration to lose its validity.

Code	ContaminationSensor
Type	CS1000 series
Part no.	-
Serial no.	-
EMC Guideline	2004/108/EG
EU directive on electromagnetic compatibility	DIN EN 55011:1998 + A1:1999 + A2:2002
Electromagnetic compatibility, immunity	EN 61000-6-2

2012-08-21	Thorsten Trier	
Date	Name	(CE official)

Executive director:
Mathias Dieter, Dipl.Kfm. Wolfgang Haering
Registered seat of company: 66280 Sulzbach / Saar - Germany
Registry Court: Saarbrücken, HRB 17216
Value added tax identification number: DE 815001609
Tax number : 040/110/50773

Documentation Representative:
Mr. Günter Harge
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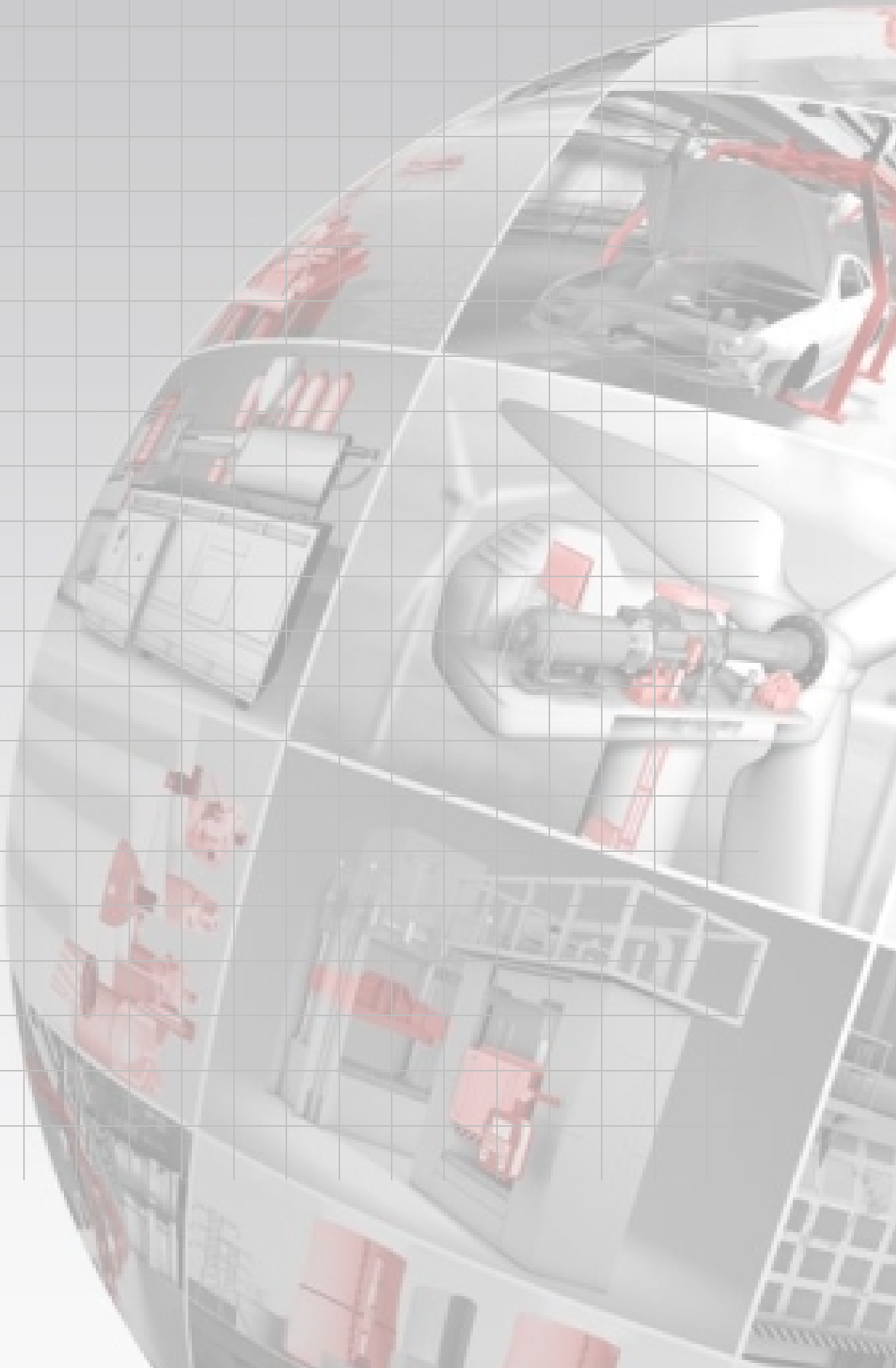

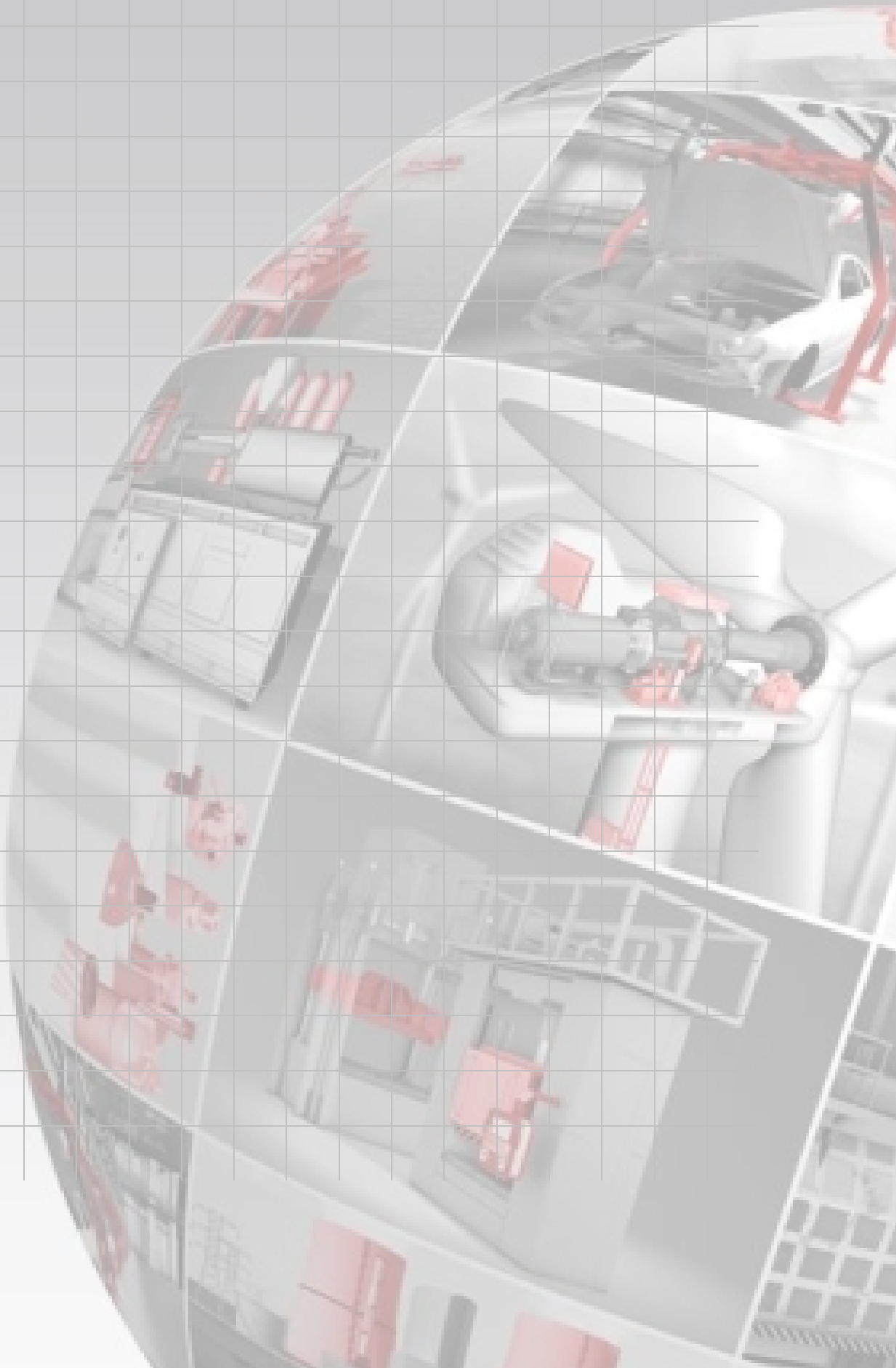

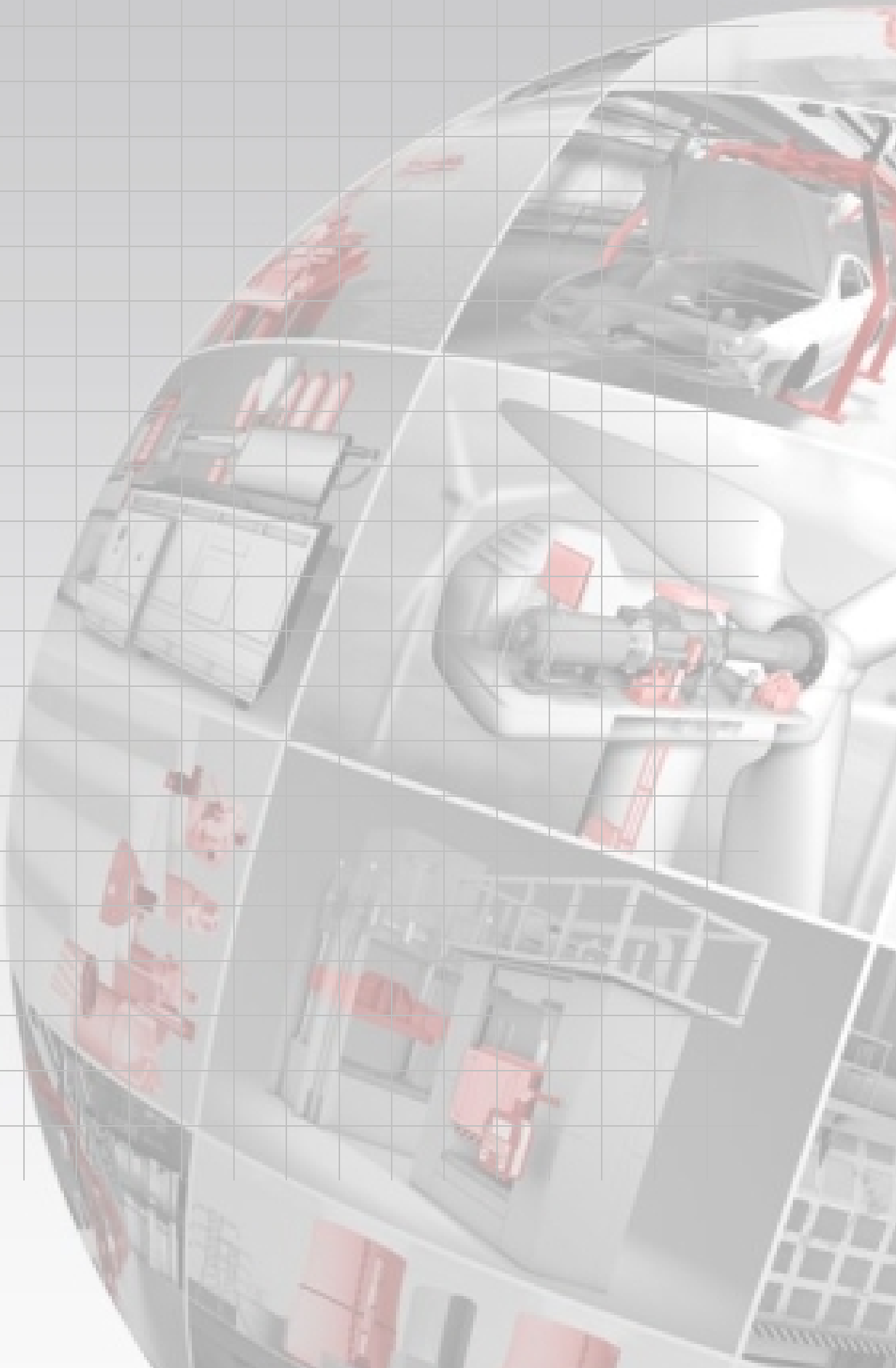

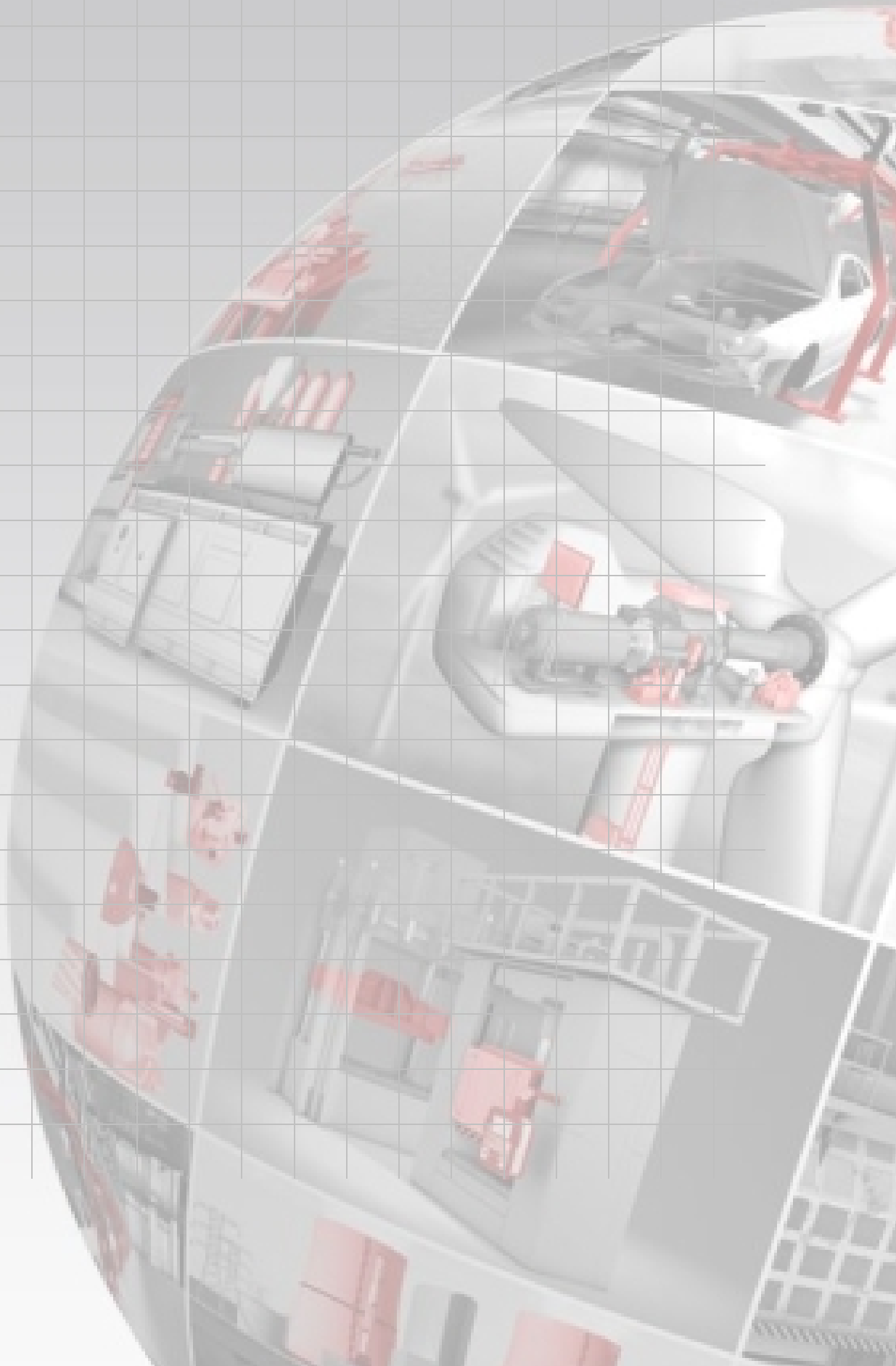

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